Triangles

1.0.1

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Chapter 1

Namespace Index

1.1 Namespace List

Here is a list of all namespaces with brief descriptions:

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 3

File Index

3.1 File List

Here is a list of all files with brief descriptions:

Chapter 4

Namespace Documentation

4.1 geom Namespace Reference

line.hh Line class implementation

Namespaces

- detail
- kdtree

Classes

- struct BoundBox
- class Line

  Line class implementation.
- class Plane

  Plane class realization.
- class ThresComp
- class Triangle

  Triangle class implementation.
- class Vec2

  Vec2 class realization.
- class Vec3

  Vec3 class realization.

Typedefs

- using Vec2D = Vec2< double >
- using Vec2F = Vec2< float >
- using Vec3D = Vec3< double >
- using Vec3F = Vec3< float >

Enumerations

- enum Axis : std::int8_t { Axis::X = 0, Axis::Y = 1, Axis::Z = 2, Axis::NONE }

Functions

- template<std::floating_point T>
  T distance (const Plane< T > &pl, const Vec3< T > &pt)

  Calculates signed distance between point and plane.
- template<std::floating_point T>
  bool isIntersect (const Triangle< T > &tr1, const Triangle< T > &tr2)

  Checks intersection of 2 triangles.
- template<std::floating_point T>
  std::variant< std::monostate, Line< T >, Plane< T > > intersect (const Plane< T > &pl1, const Plane< T > &pl2)

  Intersect 2 planes and return result of intersection.
- template<std::floating_point T>
  std::variant< std::monostate, Vec3< T >, Line< T > > intersect (const Line< T > &l1, const Line< T > &l2)

  Intersect 2 lines and return result of intersection.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const BoundBox< T > &bb)
- template<Number T>
  bool isEqualThreshold (T num1, T num2)
- template<Number T>
  bool isZeroThreshold (T num)
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Line< T > &line)

  Line print operator.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Plane< T > &pl)

  Plane print operator.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Triangle< T > &tr)

  Triangle print operator.
- template<std::floating_point T>
  std::istream & operator>> (std::istream &ist, Triangle< T > &tr)
- template<std::floating_point T>
  Vec2< T > operator+ (const Vec2< T > &lhs, const Vec2< T > &rhs)

  Overloaded + operator.
- template<std::floating_point T>
  Vec2< T > operator- (const Vec2< T > &lhs, const Vec2< T > &rhs)

  Overloaded - operator.
- template<Number nT, std::floating_point T>
  Vec2< T > operator* (const nT &val, const Vec2< T > &rhs)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec2< T > operator* (const Vec2< T > &lhs, const nT &val)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec2< T > operator/ (const Vec2< T > &lhs, const nT &val)

  Overloaded divide by value operator.

- template<std::floating_point T>
  T dot (const Vec2< T > &lhs, const Vec2< T > &rhs)

  Dot product function.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Vec2< T > &vec)

  Vec2 print operator.
- template<std::floating_point T>
  Vec3< T > operator+ (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Overloaded + operator.
- template<std::floating_point T>
  Vec3< T > operator- (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Overloaded - operator.
- template<Number nT, std::floating_point T>
  Vec3< T > operator* (const nT &val, const Vec3< T > &rhs)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec3< T > operator* (const Vec3< T > &lhs, const nT &val)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec3< T > operator/ (const Vec3< T > &lhs, const nT &val)

  Overloaded divide by value operator.
- template<std::floating_point T>
  T dot (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Dot product function.
- template<std::floating_point T>
  Vec3< T > cross (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Cross product function.
- template<std::floating_point T>
  T triple (const Vec3< T > &v1, const Vec3< T > &v2, const Vec3< T > &v3)

  Triple product function.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Vec3< T > &vec)

  Vec3 print operator.
- template<std::floating_point T>
  std::istream & operator>> (std::istream &ist, Vec3< T > &vec)

  Vec3 scan operator.

Variables

- template<class T >
  concept Number = std::is_floating_point_v<T> || std::is_integral_v<T>

  Useful concept which represents floating point and integral types.

4.1.1 Detailed Description

line.hh Line class implementation

triangle.hh Triangle class implementation

Plane class implementation.

4.1.2 Typedef Documentation

4.1.2.1 Vec2D

```
using geom::Vec2D = typedef Vec2<double>
```

Definition at line 328 of file vec2.hh.

4.1.2.2 Vec2F

```
using geom::Vec2F = typedef Vec2<float>
```

Definition at line 329 of file vec2.hh.

4.1.2.3 Vec3D

```
using geom::Vec3D = typedef Vec3<double>
```

Definition at line 374 of file vec3.hh.

4.1.2.4 Vec3F

```
using geom::Vec3F = typedef Vec3<float>
```

Definition at line 375 of file vec3.hh.

4.1.3 Enumeration Type Documentation

4.1.3.1 Axis

```
enum geom::Axis : std::int8_t [strong]
```

Enumerator

X	
Y	
Z	
NONE	

Definition at line 19 of file common.hh.

4.1.4 Function Documentation

4.1.4.1 distance()

```
template<std::floating_point T>
T geom::distance (
            const Plane< T > & pl,
            const Vec3< T > & pt )
```

Calculates signed distance between point and plane.

Template Parameters

T	- floating point type of coordinates

Parameters

pl	plane
pt	point

Returns

T signed distance between point and plane

Definition at line 26 of file distance.hh.

References geom::Plane< T >::dist(), dot(), and geom::Plane< T >::norm().

Referenced by geom::detail::getSegment(), geom::detail::getTrian2(), geom::detail::isIntersectValidInvalid(), and geom::detail::roguePos().

4.1.4.2 isIntersect()

```
template<std::floating_point T>
bool geom::isIntersect (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Checks intersection of 2 triangles.

Template Parameters

T	- floating point type of coordinates

Parameters

tr1	first triangle
tr2	second triangle

Returns

true if triangles are intersect

false if triangles are not intersect

Definition at line 156 of file intersection.hh.

References geom::Triangle< T >::getPlane(), geom::detail::isIntersect2D(), geom::detail::isIntersectBothInvalid(), geom::detail::isIntersectMollerHaines(), geom::detail::isIntersectValidInvalid(), geom::detail::isOnOneSide(), and geom::Triangle< T >::isValid().

4.1.4.3 intersect() [1/2]

```
template<std::floating_point T>
std::variant< std::monostate, Line< T >, Plane< T > > geom::intersect (
            const Plane< T > & pl1,
            const Plane< T > & pl2 )
```

Intersect 2 planes and return result of intersection.

Common intersection case (parallel planes case is trivial):

Let $\overrightarrow{P}$ - point in space

pl_1 equation: $\overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1$

pl_2 equation: $\overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2$

Intersection line direction: $\overrightarrow{dir} = \overrightarrow{n}_1 \times \overrightarrow{n}_2$

Let origin of intersection line be a linear combination of $\overrightarrow{n}_1$ and $\overrightarrow{n}_2$:

$$\overrightarrow{P} = a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2$$

$\overrightarrow{P}$ must satisfy both pl_1 and pl_1 equations:

$$\overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1 \Leftrightarrow \overrightarrow{n}_1 \cdot (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) = d_1 \Leftrightarrow a + b \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 = d_1$$

$$\overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2 \Leftrightarrow \overrightarrow{n}_2 \cdot (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) = d_2 \Leftrightarrow a \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 + b = d_2$$

Let's find a and b:

$$a = \frac{d_2 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_1}{(\overrightarrow{n}_1 \cdot \overrightarrow{n}_2)^2 - 1}$$

$$b = \frac{d_1 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_2}{(\overrightarrow{n}_1 \cdot \overrightarrow{n}_2)^2 - 1}$$

Intersection line equation:

$$\overrightarrow{r}(t) = \overrightarrow{P} + t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2 = (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) + t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2$$

Template Parameters

T	- floating point type of coordinates

Parameters

in	*pl1*	first plane
in	*pl2*	second plane

Returns

std::variant<std::monostate, Line<T>, Plane<T>>

Definition at line 188 of file intersection.hh.

References cross(), geom::Plane< T >::dist(), dot(), and geom::Plane< T >::norm().

Referenced by geom::detail::isIntersectMollerHaines(), and geom::detail::isIntersectSegmentSegment().

4.1.4.4 intersect() [2/2]

```
template<std::floating_point T>
std::variant< std::monostate, Vec3< T >, Line< T > > geom::intersect (
            const Line< T > & l1,
            const Line< T > & l2 )
```

Intersect 2 lines and return result of intersection.

Common intersection case (parallel & skew lines cases are trivial): Let $\overrightarrow{P}$ - point in space, intersection point of two lines.

l_1 equation: $\overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 = \overrightarrow{P}$

l_2 equation: $\overrightarrow{org}_2 + \overrightarrow{dir}_2 \cdot t_2 = \overrightarrow{P}$

Let's equate left sides:

$$\overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 = \overrightarrow{org}_2 + \overrightarrow{dir}_2 \cdot t_2$$

Cross multiply both sides from right by $\overrightarrow{dir}_2$:

$$t_1 \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right) = (\overrightarrow{org}_2 - \overrightarrow{org}_1) \times \overrightarrow{dir}_2$$

Dot multiply both sides by $\frac{\overrightarrow{dir}_1 \times \overrightarrow{dir}_2}{\left|\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right|^2}$:

$$t_1 = \frac{\left((\overrightarrow{org}_2 - \overrightarrow{org}_1) \times \overrightarrow{dir}_2\right) \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right)}{\left|\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right|^2}$$

Thus we get intersection point parameter t_1 on l_1, let's substitute it to l_1 equation:

$$\overrightarrow{P} = \overrightarrow{org}_1 + \frac{\left((\overrightarrow{org}_2 - \overrightarrow{org}_1) \times \overrightarrow{dir}_2\right) \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right)}{\left|\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right|^2} \cdot \overrightarrow{dir}_1$$

Template Parameters

T	- floating point type of coordinates

Parameters

in	*l1*	first line
in	*l2*	second line

Returns

std::variant<std::monostate, Vec3<T>, Line<T>>

Definition at line 215 of file intersection.hh.

References cross(), geom::Line< T >::dir(), dot(), geom::Line< T >::getPoint(), geom::Line< T >::isEqual(), geom::Line< T >::isPar(), geom::Line< T >::isSkew(), and geom::Line< T >::org().

4.1.4.5 operator<<() [1/6]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const BoundBox< T > & bb )
```

Definition at line 127 of file boundbox.hh.

References geom::BoundBox< T >::maxX, geom::BoundBox< T >::maxY, geom::BoundBox< T >::maxZ, geom::BoundBox< T >::minX, geom::BoundBox< T >::minY, and geom::BoundBox< T >::minZ.

4.1.4.6 isEqualThreshold()

```
template<Number T>
bool geom::isEqualThreshold (
            T num1,
            T num2 )
```

Definition at line 71 of file common.hh.

Referenced by geom::Plane< T >::belongs(), geom::Vec2< T >::isEqual(), geom::Vec3< T >::isEqual(), geom::Vec2< T >::normalize(), geom::Vec3< T >::normalize(), and geom::BoundBox< T >::operator==().

4.1.4.7 isZeroThreshold()

```
template<Number T>
bool geom::isZeroThreshold (
            T num )
```

Definition at line 77 of file common.hh.

References geom::ThresComp< T >::isZero().

Referenced by geom::detail::isAllPosNeg(), geom::detail::isIntersectValidInvalid(), geom::Vec2< T >::isPar(), geom::Vec2< T >::isPerp(), geom::Vec3< T >::isPerp(), geom::Line< T >::isSkew(), geom::Vec2< T >::normalize(), and geom::Vec3< T >::normalize().

4.1.4.8 operator<<() [2/6]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Line< T > & line )
```

Line print operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in,out	*ost*	output stream
in	*line*	Line to print

Returns

std::ostream& modified ostream instance

Definition at line 151 of file line.hh.

References geom::Line< T >::dir(), and geom::Line< T >::org().

4.1.4.9 operator<<() [3/6]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Plane< T > & pl )
```

Plane print operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in,out	*ost*	output stream
in	*pl*	plane to print

Returns

std::ostream& modified ostream instance

Definition at line 169 of file plane.hh.

References geom::Plane< T >::dist(), and geom::Plane< T >::norm().

4.1.4.10 operator<<() [4/6]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Triangle< T > & tr )
```

Triangle print operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in,out	*ost*	output stream
in	*tr*	Triangle to print

Returns

std::ostream& modified ostream instance

Definition at line 141 of file triangle.hh.

4.1.4.11 operator>>() [1/2]

```
template<std::floating_point T>
std::istream& geom::operator>> (
```

```
            std::istream & ist,
            Triangle< T > & tr )
```

Definition at line 153 of file triangle.hh.

4.1.4.12 operator+() [1/2]

```
template<std::floating_point T>
Vec2<T> geom::operator+ (
            const Vec2< T > & lhs,
            const Vec2< T > & rhs )
```

Overloaded + operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

Vec2<T> sum of two vectors

Definition at line 225 of file vec2.hh.

4.1.4.13 operator-() [1/2]

```
template<std::floating_point T>
Vec2<T> geom::operator- (
            const Vec2< T > & lhs,
            const Vec2< T > & rhs )
```

Overloaded - operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

Vec2<T> res of two vectors

Definition at line 241 of file vec2.hh.

4.1.4.14 operator*() [1/4]

```
template<Number nT, std::floating_point T>
Vec2<T> geom::operator* (
            const nT & val,
            const Vec2< T > & rhs )
```

Overloaded multiple by value operator.

Template Parameters

nT	type of value to multiply by
T	vector template parameter

Parameters

in	*val*	value to multiply by
in	*rhs*	vector to multiply by value

Returns

Vec2<T> result vector

Definition at line 258 of file vec2.hh.

4.1.4.15 operator*() [2/4]

```
template<Number nT, std::floating_point T>
Vec2<T> geom::operator* (
            const Vec2< T > & lhs,
            const nT & val )
```

Overloaded multiple by value operator.

Template Parameters

nT	type of value to multiply by
T	vector template parameter

Parameters

in	*val*	value to multiply by
in	*lhs*	vector to multiply by value

Returns

Vec2<T> result vector

Definition at line 275 of file vec2.hh.

4.1.4.16 operator/() [1/2]

```
template<Number nT, std::floating_point T>
Vec2<T> geom::operator/ (
            const Vec2< T > & lhs,
            const nT & val )
```

Overloaded divide by value operator.

Template Parameters

nT	type of value to divide by
T	vector template parameter

Parameters

in	*val*	value to divide by
in	*lhs*	vector to divide by value

Returns

Vec2<T> result vector

Definition at line 292 of file vec2.hh.

4.1.4.17 dot() [1/2]

```
template<std::floating_point T>
T geom::dot (
            const Vec2< T > & lhs,
            const Vec2< T > & rhs )
```

Dot product function.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

T dot production

Definition at line 308 of file vec2.hh.

References geom::Vec2< T >::dot().

Referenced by distance(), intersect(), geom::detail::isIntersectPointSegment(), geom::detail::isIntersectPointTriangle(), geom::detail::isIntersectSegmentSegment(), geom::Vec2< T >::isPerp(), geom::Vec3< T >::isPerp(), geom::Vec2< T >::length2(), geom::Vec3< T >::length2(), and triple().

4.1.4.18 operator<<() [5/6]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Vec2< T > & vec )
```

Vec2 print operator.

Template Parameters

T	vector template parameter

Parameters

in,out	*ost*	output stream
in	*vec*	vector to print

Returns

std::ostream& modified stream instance

Definition at line 322 of file vec2.hh.

References geom::Vec2< T >::x, and geom::Vec2< T >::y.

4.1.4.19 operator+() [2/2]

```
template<std::floating_point T>
Vec3<T> geom::operator+ (
            const Vec3< T > & lhs,
            const Vec3< T > & rhs )
```

Overloaded + operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

Vec3<T> sum of two vectors

Definition at line 227 of file vec3.hh.

4.1.4.20 operator-() [2/2]

```
template<std::floating_point T>
Vec3<T> geom::operator- (
            const Vec3< T > & lhs,
            const Vec3< T > & rhs )
```

Overloaded - operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

Vec3<T> res of two vectors

Definition at line 243 of file vec3.hh.

4.1.4.21 operator*() [3/4]

```
template<Number nT, std::floating_point T>
Vec3<T> geom::operator* (
            const nT & val,
            const Vec3< T > & rhs )
```

Overloaded multiple by value operator.

Template Parameters

nT	type of value to multiply by
T	vector template parameter

Parameters

in	*val*	value to multiply by
in	*rhs*	vector to multiply by value

Returns

Vec3<T> result vector

Definition at line 260 of file vec3.hh.

4.1.4.22 operator*() [4/4]

```
template<Number nT, std::floating_point T>
Vec3<T> geom::operator* (
            const Vec3< T > & lhs,
            const nT & val )
```

Overloaded multiple by value operator.

Template Parameters

nT	type of value to multiply by
T	vector template parameter

Parameters

in	*val*	value to multiply by
in	*lhs*	vector to multiply by value

Returns

Vec3<T> result vector

Definition at line 277 of file vec3.hh.

4.1.4.23 operator/() [2/2]

```
template<Number nT, std::floating_point T>
Vec3<T> geom::operator/ (
            const Vec3< T > & lhs,
            const nT & val )
```

Overloaded divide by value operator.

Template Parameters

nT	type of value to divide by
T	vector template parameter

Parameters

in	*val*	value to divide by
in	*lhs*	vector to divide by value

Returns

Vec3<T> result vector

Definition at line 294 of file vec3.hh.

4.1.4.24 dot() [2/2]

```
template<std::floating_point T>
T geom::dot (
            const Vec3< T > & lhs,
            const Vec3< T > & rhs )
```

Dot product function.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

T dot production

Definition at line 310 of file vec3.hh.

References geom::Vec3< T >::dot().

4.1.4.25 cross()

```
template<std::floating_point T>
Vec3<T> geom::cross (
            const Vec3< T > & lhs,
            const Vec3< T > & rhs )
```

Cross product function.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

T cross production

Definition at line 324 of file vec3.hh.

References geom::Vec3< T >::cross().

Referenced by intersect(), geom::Vec3< T >::isPar(), geom::Triangle< T >::isValid(), and triple().

4.1.4.26 triple()

```
template<std::floating_point T>
T geom::triple (
            const Vec3< T > & v1,
            const Vec3< T > & v2,
            const Vec3< T > & v3 )
```

Triple product function.

Template Parameters

T	vector template parameter

Parameters

in	*v1*	first vector
in	*v2*	second vector
in	*v3*	third vector

Returns

T triple production

Definition at line 339 of file vec3.hh.

References cross(), and dot().

Referenced by geom::Line< T >::isSkew().

4.1.4.27 operator<<() [6/6]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Vec3< T > & vec )
```

Vec3 print operator.

Template Parameters

T	vector template parameter

Parameters

in,out	*ost*	output stream
in	*vec*	vector to print

Returns

std::ostream& modified stream instance

Definition at line 353 of file vec3.hh.

References geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

4.1.4.28 operator>>() [2/2]

```
template<std::floating_point T>
std::istream& geom::operator>> (
            std::istream & ist,
            Vec3< T > & vec )
```

Vec3 scan operator.

Template Parameters

T	vector template parameter

Parameters

in,out	*ist*	input stram
in,out	*vec*	vector to scan

Returns

std::istream& modified stream instance

Definition at line 368 of file vec3.hh.

References geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

4.1.5 Variable Documentation

4.1.5.1 Number

```
template<class T >
concept geom::Number = std::is_floating_point_v<T> || std::is_integral_v<T>
```

Useful concept which represents floating point and integral types.

@concept Number

Template Parameters

T	

Definition at line 17 of file common.hh.

4.2 geom::detail Namespace Reference

Typedefs

- template<typename T >
  using Segment2D = std::pair< T, T >
- template<std::floating_point T>
  using Trian2 = std::array< Vec2< T >, 3 >
- template<std::floating_point T>
  using Segment3D = std::pair< Vec3< T >, Vec3< T > >

Functions

- template<std::floating_point T>
  bool isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  bool isIntersectMollerHaines (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  Segment2D< T > helperMollerHaines (const Triangle< T > &tr, const Plane< T > &pl, const Line< T > &l)
- template<std::floating_point T>
  bool isIntersectBothInvalid (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  bool isIntersectValidInvalid (const Triangle< T > &valid, const Triangle< T > &invalid)
- template<std::floating_point T>
  bool isIntersectPointTriangle (const Vec3< T > &pt, const Triangle< T > &tr)
- template<std::floating_point T>
  bool isIntersectPointSegment (const Vec3< T > &pt, const Segment3D< T > &segm)
- template<std::floating_point T>
  bool isIntersectSegmentSegment (const Segment3D< T > &segm1, const Segment3D< T > &segm2)
- template<std::floating_point T>
  bool isPoint (const Triangle< T > &tr)
- template<std::floating_point T>
  bool isOverlap (Segment2D< T > &segm1, Segment2D< T > &segm2)
- template<std::forward_iterator It>
  bool isAllPosNeg (It begin, It end)
- template<std::floating_point T>
  bool isAllPosNeg (T num1, T num2)
- template<std::floating_point T>
  bool isOnOneSide (const Plane< T > &pl, const Triangle< T > &tr)
- template<std::floating_point T>
  Trian2< T > getTrian2 (const Plane< T > &pl, const Triangle< T > &tr)
- template<std::floating_point T>
  bool isCounterClockwise (Trian2< T > &tr)
- template<std::floating_point T>
  Segment2D< T > computeInterval (const Trian2< T > &tr, const Vec2< T > &d)
- template<std::floating_point T>
  Segment3D< T > getSegment (const Triangle< T > &tr)
- template<std::bidirectional_iterator It>
  std::size_t roguePos (It begin, It end)

4.2.1 Typedef Documentation

4.2.1.1 Segment2D

```
template<typename T >
using geom::detail::Segment2D = typedef std::pair<T, T>
```

Definition at line 15 of file detail.hh.

4.2.1.2 Trian2

```
template<std::floating_point T>
using geom::detail::Trian2 = typedef std::array<Vec2<T>, 3>
```

Definition at line 18 of file detail.hh.

4.2.1.3 Segment3D

```
template<std::floating_point T>
using geom::detail::Segment3D = typedef std::pair<Vec3<T>, Vec3<T> >
```

Definition at line 21 of file detail.hh.

4.2.2 Function Documentation

4.2.2.1 isIntersect2D()

```
template<std::floating_point T>
bool geom::detail::isIntersect2D (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Definition at line 80 of file detail.hh.

References computeInterval(), geom::Triangle< T >::getPlane(), and getTrian2().

Referenced by geom::isIntersect(), and isIntersectValidInvalid().

4.2.2.2 isIntersectMollerHaines()

```
template<std::floating_point T>
bool geom::detail::isIntersectMollerHaines (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Definition at line 103 of file detail.hh.

References geom::Triangle< T >::getPlane(), helperMollerHaines(), geom::intersect(), and isOverlap().

Referenced by geom::isIntersect().

4.2.2.3 helperMollerHaines()

```
template<std::floating_point T>
Segment2D< T > geom::detail::helperMollerHaines (
            const Triangle< T > & tr,
            const Plane< T > & pl,
            const Line< T > & l )
```

Definition at line 117 of file detail.hh.

References geom::Triangle< T >::begin(), geom::Line< T >::dir(), geom::Triangle< T >::end(), geom::Line< T >::org(), and roguePos().

Referenced by isIntersectMollerHaines().

4.2.2.4 isIntersectBothInvalid()

```
template<std::floating_point T>
bool geom::detail::isIntersectBothInvalid (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Definition at line 140 of file detail.hh.

References getSegment(), isIntersectPointSegment(), isIntersectSegmentSegment(), and isPoint().

Referenced by geom::isIntersect().

4.2.2.5 isIntersectValidInvalid()

```
template<std::floating_point T>
bool geom::detail::isIntersectValidInvalid (
            const Triangle< T > & valid,
            const Triangle< T > & invalid )
```

Definition at line 158 of file detail.hh.

References geom::distance(), geom::Triangle< T >::getPlane(), getSegment(), isIntersect2D(), isIntersectPointTriangle(), isPoint(), and geom::isZeroThreshold().

Referenced by geom::isIntersect().

4.2.2.6 isIntersectPointTriangle()

```
template<std::floating_point T>
bool geom::detail::isIntersectPointTriangle (
            const Vec3< T > & pt,
            const Triangle< T > & tr )
```

Definition at line 183 of file detail.hh.

References geom::dot(), and geom::Triangle< T >::getPlane().

Referenced by isIntersectValidInvalid().

4.2.2.7 isIntersectPointSegment()

```
template<std::floating_point T>
bool geom::detail::isIntersectPointSegment (
            const Vec3< T > & pt,
            const Segment3D< T > & segm )
```

Definition at line 211 of file detail.hh.

References geom::dot(), and isAllPosNeg().

Referenced by isIntersectBothInvalid(), and isIntersectSegmentSegment().

4.2.2.8 isIntersectSegmentSegment()

```
template<std::floating_point T>
bool geom::detail::isIntersectSegmentSegment (
            const Segment3D< T > & segm1,
            const Segment3D< T > & segm2 )
```

Definition at line 224 of file detail.hh.

References geom::dot(), geom::intersect(), isIntersectPointSegment(), and isOverlap().

Referenced by isIntersectBothInvalid().

4.2.2.9 isPoint()

```
template<std::floating_point T>
bool geom::detail::isPoint (
            const Triangle< T > & tr )
```

Definition at line 248 of file detail.hh.

Referenced by isIntersectBothInvalid(), and isIntersectValidInvalid().

4.2.2.10 isOverlap()

```
template<std::floating_point T>
bool geom::detail::isOverlap (
            Segment2D< T > & segm1,
            Segment2D< T > & segm2 )
```

Definition at line 254 of file detail.hh.

Referenced by isIntersectMollerHaines(), and isIntersectSegmentSegment().

4.2.2.11 isAllPosNeg() [1/2]

```
template<std::forward_iterator It>
bool geom::detail::isAllPosNeg (
            It begin,
            It end )
```

Definition at line 260 of file detail.hh.

References geom::isZeroThreshold().

Referenced by isIntersectPointSegment(), isOnOneSide(), and roguePos().

4.2.2.12 isAllPosNeg() [2/2]

```
template<std::floating_point T>
bool geom::detail::isAllPosNeg (
            T num1,
            T num2 )
```

Definition at line 271 of file detail.hh.

4.2.2.13 isOnOneSide()

```
template<std::floating_point T>
bool geom::detail::isOnOneSide (
            const Plane< T > & pl,
            const Triangle< T > & tr )
```

Definition at line 278 of file detail.hh.

References geom::Triangle< T >::begin(), geom::Triangle< T >::end(), and isAllPosNeg().

Referenced by geom::isIntersect().

4.2.2.14 getTrian2()

```
template<std::floating_point T>
Trian2< T > geom::detail::getTrian2 (
            const Plane< T > & pl,
            const Triangle< T > & tr )
```

Definition at line 286 of file detail.hh.

References geom::distance(), isCounterClockwise(), and geom::Plane< T >::norm().

Referenced by isIntersect2D().

4.2.2.15 isCounterClockwise()

```
template<std::floating_point T>
bool geom::detail::isCounterClockwise (
            Trian2< T > & tr )
```

Definition at line 320 of file detail.hh.

Referenced by getTrian2().

4.2.2.16 computeInterval()

```
template<std::floating_point T>
Segment2D< T > geom::detail::computeInterval (
            const Trian2< T > & tr,
            const Vec2< T > & d )
```

Definition at line 340 of file detail.hh.

Referenced by isIntersect2D().

4.2.2.17 getSegment()

```
template<std::floating_point T>
Segment3D< T > geom::detail::getSegment (
            const Triangle< T > & tr )
```

Definition at line 349 of file detail.hh.

References geom::distance().

Referenced by isIntersectBothInvalid(), and isIntersectValidInvalid().

4.2.2.18 roguePos()

```
template<std::bidirectional_iterator It>
std::size_t geom::detail::roguePos (
            It begin,
            It end )
```

Definition at line 362 of file detail.hh.

References geom::distance(), and isAllPosNeg().

Referenced by helperMollerHaines().

4.3 geom::kdtree Namespace Reference

Classes

- class Container
- class KdTree
- struct Node

Typedefs

- using Index = std::size_t

4.3.1 Typedef Documentation

4.3.1.1 Index

```
using geom::kdtree::Index = typedef std::size_t
```

Definition at line 13 of file node.hh.

Chapter 5

Class Documentation

5.1 geom::BoundBox< T > Struct Template Reference

`#include <boundbox.hh>`

Public Member Functions

- bool belongsTo (const BoundBox< T > &bb)
- T & min (Axis axis) &
- T & max (Axis axis) &
- T min (Axis axis) &&
- T max (Axis axis) &&
- T min (Axis axis) const &
- T max (Axis axis) const &
- Axis getMaxDim () const
- bool operator== (const BoundBox &rhs) const
- bool operator!= (const BoundBox &rhs) const

Public Attributes

- T minX {}
- T maxX {}
- T minY {}
- T maxY {}
- T minZ {}
- T maxZ {}

5.1.1 Detailed Description

template<std::floating_point T>
struct geom::BoundBox< T >

Definition at line 14 of file boundbox.hh.

5.1.2 Member Function Documentation

5.1.2.1 belongsTo()

```
template<std::floating_point T>
bool geom::BoundBox< T >::belongsTo (
            const BoundBox< T > & bb )
```

Definition at line 43 of file boundbox.hh.

References geom::BoundBox< T >::maxX, geom::BoundBox< T >::maxY, geom::BoundBox< T >::maxZ, geom::BoundBox< T >::minX, geom::BoundBox< T >::minY, and geom::BoundBox< T >::minZ.

5.1.2.2 min() [1/3]

```
template<std::floating_point T>
T & geom::BoundBox< T >::min (
            Axis axis ) &
```

Definition at line 67 of file boundbox.hh.

References BBFILL.

5.1.2.3 max() [1/3]

```
template<std::floating_point T>
T & geom::BoundBox< T >::max (
            Axis axis ) &
```

Definition at line 73 of file boundbox.hh.

References BBFILL.

5.1.2.4 min() [2/3]

```
template<std::floating_point T>
T geom::BoundBox< T >::min (
            Axis axis ) &&
```

Definition at line 79 of file boundbox.hh.

References BBFILL.

5.1.2.5 max() [2/3]

```
template<std::floating_point T>
T geom::BoundBox< T >::max (
            Axis axis ) &&
```

Definition at line 85 of file boundbox.hh.

References BBFILL.

5.1.2.6 min() [3/3]

```
template<std::floating_point T>
T geom::BoundBox< T >::min (
            Axis axis ) const &
```

Definition at line 91 of file boundbox.hh.

References BBFILL.

5.1.2.7 max() [3/3]

```
template<std::floating_point T>
T geom::BoundBox< T >::max (
            Axis axis ) const &
```

Definition at line 97 of file boundbox.hh.

References BBFILL.

5.1.2.8 getMaxDim()

```
template<std::floating_point T>
Axis geom::BoundBox< T >::getMaxDim
```

Definition at line 105 of file boundbox.hh.

References geom::X, geom::Y, and geom::Z.

5.1.2.9 operator==()

```
template<std::floating_point T>
bool geom::BoundBox< T >::operator== (
            const BoundBox< T > & rhs ) const
```

Definition at line 113 of file boundbox.hh.

References geom::isEqualThreshold(), geom::BoundBox< T >::maxX, geom::BoundBox< T >::maxY, geom::BoundBox< T >::minX, geom::BoundBox< T >::minY, and geom::BoundBox< T >::minZ.

5.1.2.10 operator"!=()

```
template<std::floating_point T>
bool geom::BoundBox< T >::operator!= (
            const BoundBox< T > & rhs ) const
```

Definition at line 121 of file boundbox.hh.

5.1.3 Member Data Documentation

5.1.3.1 minX

```
template<std::floating_point T>
T geom::BoundBox< T >::minX {}
```

Definition at line 16 of file boundbox.hh.

Referenced by geom::BoundBox< T >::belongsTo(), geom::operator<<(), and geom::BoundBox< T >::operator==().

5.1.3.2 maxX

```
template<std::floating_point T>
T geom::BoundBox< T >::maxX {}
```

Definition at line 17 of file boundbox.hh.

Referenced by geom::BoundBox< T >::belongsTo(), geom::operator<<(), and geom::BoundBox< T >::operator==().

5.1.3.3 minY

```
template<std::floating_point T>
T geom::BoundBox< T >::minY {}
```

Definition at line 19 of file boundbox.hh.

Referenced by geom::BoundBox< T >::belongsTo(), geom::operator<<(), and geom::BoundBox< T >::operator==().

5.1.3.4 maxY

```
template<std::floating_point T>
T geom::BoundBox< T >::maxY {}
```

Definition at line 20 of file boundbox.hh.

Referenced by geom::BoundBox< T >::belongsTo(), geom::operator<<(), and geom::BoundBox< T >::operator==().

5.1.3.5 minZ

```
template<std::floating_point T>
T geom::BoundBox< T >::minZ {}
```

Definition at line 22 of file boundbox.hh.

Referenced by geom::BoundBox< T >::belongsTo(), geom::operator<<(), and geom::BoundBox< T >::operator==().

5.1.3.6 maxZ

```
template<std::floating_point T>
T geom::BoundBox< T >::maxZ {}
```

Definition at line 23 of file boundbox.hh.

Referenced by geom::BoundBox< T >::belongsTo(), and geom::operator<<().

The documentation for this struct was generated from the following file:

- include/primitives/boundbox.hh

5.2 geom::kdtree::Container< T > Class Template Reference

```
#include <container.hh>
```

Classes

- class ConstIterator

Public Member Functions

- Container (const KdTree< T > *tree, const Node< T > *node)
- ConstIterator cbegin () const &
- ConstIterator cend () const &
- ConstIterator begin () const &
- ConstIterator end () const &
- Node< T >::IndexConstIterator indexBegin () const &
- Node< T >::IndexConstIterator indexEnd () const &
- T separator () const
- Axis sepAxis () const
- BoundBox< T > boundBox () const
- const Triangle< T > & triangleByIndex (Index index) const &
- Container left () const
- Container right () const
- bool isValid () const

5.2.1 Detailed Description

template<std::floating_point T>
class geom::kdtree::Container< T >

Definition at line 16 of file container.hh.

5.2.2 Constructor & Destructor Documentation

5.2.2.1 Container()

```
template<std::floating_point T>
geom::kdtree::Container< T >::Container (
            const KdTree< T > * tree,
            const Node< T > * node )
```

Definition at line 78 of file container.hh.

5.2.3 Member Function Documentation

5.2.3.1 cbegin()

```
template<std::floating_point T>
Container< T >::ConstIterator geom::kdtree::Container< T >::cbegin
```

Definition at line 82 of file container.hh.

5.2.3.2 cend()

```
template<std::floating_point T>
Container< T >::ConstIterator geom::kdtree::Container< T >::cend
```

Definition at line 88 of file container.hh.

5.2.3.3 begin()

```
template<std::floating_point T>
Container< T >::ConstIterator geom::kdtree::Container< T >::begin
```

Definition at line 94 of file container.hh.

5.2.3.4 end()

```
template<std::floating_point T>
Container< T >::ConstIterator geom::kdtree::Container< T >::end
```

Definition at line 100 of file container.hh.

5.2.3.5 indexBegin()

```
template<std::floating_point T>
Node< T >::IndexConstIterator geom::kdtree::Container< T >::indexBegin
```

Definition at line 106 of file container.hh.

Referenced by geom::kdtree::Container< T >::ConstIterator::ConstIterator().

5.2.3.6 indexEnd()

```
template<std::floating_point T>
Node< T >::IndexConstIterator geom::kdtree::Container< T >::indexEnd
```

Definition at line 112 of file container.hh.

Referenced by geom::kdtree::Container< T >::ConstIterator::ConstIterator().

5.2.3.7 separator()

```
template<std::floating_point T>
T geom::kdtree::Container< T >::separator
```

Definition at line 118 of file container.hh.

5.2.3.8 sepAxis()

```
template<std::floating_point T>
Axis geom::kdtree::Container< T >::sepAxis
```

Definition at line 124 of file container.hh.

5.2.3.9 boundBox()

```
template<std::floating_point T>
BoundBox< T > geom::kdtree::Container< T >::boundBox
```

Definition at line 130 of file container.hh.

5.2.3.10 triangleByIndex()

```
template<std::floating_point T>
const Triangle< T > & geom::kdtree::Container< T >::triangleByIndex (
            Index index ) const &
```

Definition at line 136 of file container.hh.

5.2.3.11 left()

```
template<std::floating_point T>
Container< T > geom::kdtree::Container< T >::left
```

Definition at line 142 of file container.hh.

References geom::kdtree::Container< T >::left().

Referenced by geom::kdtree::Container< T >::left().

5.2.3.12 right()

```
template<std::floating_point T>
Container< T > geom::kdtree::Container< T >::right
```

Definition at line 148 of file container.hh.

References geom::kdtree::Container< T >::right().

Referenced by geom::kdtree::Container< T >::right().

5.2.3.13 isValid()

```
template<std::floating_point T>
bool geom::kdtree::Container< T >::isValid
```

Definition at line 154 of file container.hh.

The documentation for this class was generated from the following file:

- include/kdtree/container.hh

5.3 geom::kdtree::Container< T >::ConstIterator Class Reference

```
#include <container.hh>
```

Public Types

- using iterator_category = std::forward_iterator_tag
- using difference_type = std::size_t
- using value_type = Triangle< T >
- using reference = const Triangle< T > &
- using pointer = const Triangle< T > *

Public Member Functions

- ConstIterator (const Container *cont, bool isEnd=false)
- Index getIndex ()
- ConstIterator & operator++ ()
- ConstIterator operator++ (int)
- reference operator* () const
- pointer operator-> () const
- bool operator== (const ConstIterator &lhs) const =default

5.3.1 Detailed Description

template<std::floating_point T>
class geom::kdtree::Container< T >::ConstIterator

Definition at line 45 of file container.hh.

5.3.2 Member Typedef Documentation

5.3.2.1 iterator_category

```
template<std::floating_point T>
using geom::kdtree::Container< T >::ConstIterator::iterator_category = std::forward_iterator↩
_tag
```

Definition at line 48 of file container.hh.

5.3.2.2 difference_type

```
template<std::floating_point T>
using geom::kdtree::Container< T >::ConstIterator::difference_type = std::size_t
```

Definition at line 49 of file container.hh.

5.3.2.3 value_type

```
template<std::floating_point T>
using geom::kdtree::Container< T >::ConstIterator::value_type = Triangle<T>
```

Definition at line 50 of file container.hh.

5.3.2.4 reference

```
template<std::floating_point T>
using geom::kdtree::Container< T >::ConstIterator::reference = const Triangle<T> &
```

Definition at line 51 of file container.hh.

5.3.2.5 pointer

```
template<std::floating_point T>
using geom::kdtree::Container< T >::ConstIterator::pointer = const Triangle<T> *
```

Definition at line 52 of file container.hh.

5.3.3 Constructor & Destructor Documentation

5.3.3.1 ConstIterator()

```
template<std::floating_point T>
geom::kdtree::Container< T >::ConstIterator::ConstIterator (
            const Container * cont,
            bool isEnd = false )
```

Definition at line 164 of file container.hh.

References geom::kdtree::Container< T >::indexBegin(), and geom::kdtree::Container< T >::indexEnd().

5.3.4 Member Function Documentation

5.3.4.1 getIndex()

```
template<std::floating_point T>
Index geom::kdtree::Container< T >::ConstIterator::getIndex
```

Definition at line 176 of file container.hh.

5.3.4.2 operator++() [1/2]

```
template<std::floating_point T>
Container< T >::ConstIterator & geom::kdtree::Container< T >::ConstIterator::operator++
```

Definition at line 182 of file container.hh.

5.3.4.3 operator++() [2/2]

```
template<std::floating_point T>
Container< T >::ConstIterator geom::kdtree::Container< T >::ConstIterator::operator++ (
            int  )
```

Definition at line 189 of file container.hh.

5.3.4.4 operator*()

```
template<std::floating_point T>
Container< T >::ConstIterator::reference geom::kdtree::Container< T >::ConstIterator::operator*
```

Definition at line 197 of file container.hh.

5.3.4.5 operator->()

```
template<std::floating_point T>
Container< T >::ConstIterator::pointer geom::kdtree::Container< T >::ConstIterator::operator->
```

Definition at line 203 of file container.hh.

5.3.4.6 operator==()

```
template<std::floating_point T>
bool geom::kdtree::Container< T >::ConstIterator::operator== (
            const ConstIterator & lhs ) const  [default]
```

The documentation for this class was generated from the following file:

- include/kdtree/container.hh

5.4 geom::kdtree::KdTree< T > Class Template Reference

`#include <container.hh>`

Classes

- class ConstIterator
- struct ContainerPtr

Public Member Functions

- KdTree (std::initializer_list< Triangle< T >> il)
- KdTree (const KdTree &tree)
- KdTree (KdTree &&tree)=default
- KdTree ()=default
- ~KdTree ()
- KdTree & operator= (const KdTree &tree)
- KdTree & operator= (KdTree &&tree)=default
- ConstIterator cbegin () const &
- ConstIterator cend () const &
- ConstIterator begin () const &
- ConstIterator end () const &
- ConstIterator beginFrom (const ConstIterator &iter) const &
- void insert (const Triangle< T > &tr)
- void clear ()
- void setNodeCapacity (std::size_t newCap)
- bool empty () const
- std::size_t size () const
- std::size_t nodeCapacity () const
- const Triangle< T > & triangleByIndex (Index index) const &
- void dumpRecursive (std::ostream &ost=std::cout) const

Static Public Member Functions

- static bool isOnPosSide (Axis axis, T separator, const Triangle< T > &tr)
- static bool isOnNegSide (Axis axis, T separator, const Triangle< T > &tr)
- static bool isOnSide (Axis axis, T separator, const Triangle< T > &tr, std::function< bool(T, T)> comparator)

5.4.1 Detailed Description

template<std::floating_point T>
class geom::kdtree::KdTree< T >

Definition at line 13 of file container.hh.

5.4.2 Constructor & Destructor Documentation

5.4.2.1 KdTree() [1/4]

```
template<std::floating_point T>
geom::kdtree::KdTree< T >::KdTree (
            std::initializer_list< Triangle< T >> il )
```

Definition at line 119 of file kdtree.hh.

5.4.2.2 KdTree() [2/4]

```
template<std::floating_point T>
geom::kdtree::KdTree< T >::KdTree (
            const KdTree< T > & tree )
```

Definition at line 126 of file kdtree.hh.

5.4.2.3 KdTree() [3/4]

```
template<std::floating_point T>
geom::kdtree::KdTree< T >::KdTree (
            KdTree< T > && tree )  [default]
```

5.4.2.4 KdTree() [4/4]

```
template<std::floating_point T>
geom::kdtree::KdTree< T >::KdTree ( )  [default]
```

5.4.2.5 ~KdTree()

```
template<std::floating_point T>
geom::kdtree::KdTree< T >::~KdTree
```

Definition at line 134 of file kdtree.hh.

5.4.3 Member Function Documentation

5.4.3.1 operator=() [1/2]

```
template<std::floating_point T>
KdTree< T > & geom::kdtree::KdTree< T >::operator= (
            const KdTree< T > & tree )
```

Definition at line 140 of file kdtree.hh.

5.4.3.2 operator=() [2/2]

```
template<std::floating_point T>
KdTree& geom::kdtree::KdTree< T >::operator= (
            KdTree< T > && tree )  [default]
```

5.4.3.3 cbegin()

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::cbegin
```

Definition at line 149 of file kdtree.hh.

5.4.3.4 cend()

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::cend
```

Definition at line 155 of file kdtree.hh.

5.4.3.5 begin()

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::begin
```

Definition at line 161 of file kdtree.hh.

5.4.3.6 end()

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::end
```

Definition at line 167 of file kdtree.hh.

5.4.3.7 beginFrom()

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::beginFrom (
            const ConstIterator & iter ) const &
```

Definition at line 173 of file kdtree.hh.

References geom::kdtree::KdTree< T >::ConstIterator::beginFrom().

5.4.3.8 insert()

```
template<std::floating_point T>
void geom::kdtree::KdTree< T >::insert (
            const Triangle< T > & tr )
```

Definition at line 181 of file kdtree.hh.

References geom::Triangle< T >::belongsTo(), geom::Triangle< T >::boundBox(), and geom::NONE.

5.4.3.9 clear()

```
template<std::floating_point T>
void geom::kdtree::KdTree< T >::clear
```

Definition at line 201 of file kdtree.hh.

5.4.3.10 setNodeCapacity()

```
template<std::floating_point T>
void geom::kdtree::KdTree< T >::setNodeCapacity (
            std::size_t newCap )
```

Definition at line 228 of file kdtree.hh.

5.4.3.11 empty()

```
template<std::floating_point T>
bool geom::kdtree::KdTree< T >::empty
```

Definition at line 235 of file kdtree.hh.

5.4.3.12 size()

```
template<std::floating_point T>
std::size_t geom::kdtree::KdTree< T >::size
```

Definition at line 241 of file kdtree.hh.

5.4.3.13 nodeCapacity()

```
template<std::floating_point T>
std::size_t geom::kdtree::KdTree< T >::nodeCapacity
```

Definition at line 247 of file kdtree.hh.

5.4.3.14 triangleByIndex()

```
template<std::floating_point T>
const Triangle< T > & geom::kdtree::KdTree< T >::triangleByIndex (
            Index index ) const &
```

Definition at line 253 of file kdtree.hh.

5.4.3.15 dumpRecursive()

```
template<std::floating_point T>
void geom::kdtree::KdTree< T >::dumpRecursive (
            std::ostream & ost = std::cout ) const
```

Definition at line 259 of file kdtree.hh.

5.4.3.16 isOnPosSide()

```
template<std::floating_point T>
bool geom::kdtree::KdTree< T >::isOnPosSide (
            Axis axis,
            T separator,
            const Triangle< T > & tr )  [static]
```

Definition at line 268 of file kdtree.hh.

5.4.3.17 isOnNegSide()

```
template<std::floating_point T>
bool geom::kdtree::KdTree< T >::isOnNegSide (
            Axis axis,
            T separator,
            const Triangle< T > & tr )  [static]
```

Definition at line 274 of file kdtree.hh.

5.4.3.18 isOnSide()

```
template<std::floating_point T>
bool geom::kdtree::KdTree< T >::isOnSide (
            Axis axis,
            T separator,
            const Triangle< T > & tr,
            std::function< bool(T, T)> comparator )  [static]
```

Definition at line 280 of file kdtree.hh.

References geom::Triangle< T >::begin(), geom::Triangle< T >::end(), and geom::NONE.

The documentation for this class was generated from the following files:

- include/kdtree/container.hh
- include/kdtree/kdtree.hh

5.5 geom::kdtree::KdTree< T >::ConstIterator Class Reference

`#include <kdtree.hh>`

Public Types

- using iterator_category = std::forward_iterator_tag
- using difference_type = std::size_t
- using value_type = Container< T >
- using reference = Container< T >
- using pointer = ContainerPtr

Public Member Functions

- ConstIterator (const KdTree< T > *tree, const Node< T > *node)
- ConstIterator & operator++ ()
- ConstIterator operator++ (int)
- reference operator* () const
- pointer operator-> () const
- bool operator== (const ConstIterator &lhs) const
- bool operator!= (const ConstIterator &lhs) const

Static Public Member Functions

- static ConstIterator beginFrom (const ConstIterator &iter)

5.5.1 Detailed Description

template<std::floating_point T>
class geom::kdtree::KdTree< T >::ConstIterator

Definition at line 84 of file kdtree.hh.

5.5.2 Member Typedef Documentation

5.5.2.1 iterator_category

```
template<std::floating_point T>
using geom::kdtree::KdTree< T >::ConstIterator::iterator_category = std::forward_iterator_tag
```

Definition at line 87 of file kdtree.hh.

5.5.2.2 difference_type

```
template<std::floating_point T>
using geom::kdtree::KdTree< T >::ConstIterator::difference_type = std::size_t
```

Definition at line 88 of file kdtree.hh.

5.5.2.3 value_type

```
template<std::floating_point T>
using geom::kdtree::KdTree< T >::ConstIterator::value_type = Container<T>
```

Definition at line 89 of file kdtree.hh.

5.5.2.4 reference

```
template<std::floating_point T>
using geom::kdtree::KdTree< T >::ConstIterator::reference = Container<T>
```

Definition at line 90 of file kdtree.hh.

5.5.2.5 pointer

```
template<std::floating_point T>
using geom::kdtree::KdTree< T >::ConstIterator::pointer = ContainerPtr
```

Definition at line 91 of file kdtree.hh.

5.5.3 Constructor & Destructor Documentation

5.5.3.1 ConstIterator()

```
template<std::floating_point T>
geom::kdtree::KdTree< T >::ConstIterator::ConstIterator (
            const KdTree< T > * tree,
            const Node< T > * node )
```

Definition at line 414 of file kdtree.hh.

5.5.4 Member Function Documentation

5.5.4.1 operator++() [1/2]

```
template<std::floating_point T>
KdTree< T >::ConstIterator & geom::kdtree::KdTree< T >::ConstIterator::operator++
```

Definition at line 419 of file kdtree.hh.

References geom::NONE.

5.5.4.2 operator++() [2/2]

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::ConstIterator::operator++ (
            int  )
```

Definition at line 440 of file kdtree.hh.

5.5.4.3 operator*()

```
template<std::floating_point T>
KdTree< T >::ConstIterator::reference geom::kdtree::KdTree< T >::ConstIterator::operator*
```

Definition at line 448 of file kdtree.hh.

5.5.4.4 operator->()

```
template<std::floating_point T>
KdTree< T >::ConstIterator::pointer geom::kdtree::KdTree< T >::ConstIterator::operator->
```

Definition at line 454 of file kdtree.hh.

5.5.4.5 operator==()

```
template<std::floating_point T>
bool geom::kdtree::KdTree< T >::ConstIterator::operator== (
            const ConstIterator & lhs ) const
```

Definition at line 460 of file kdtree.hh.

5.5.4.6 operator"!=()

```
template<std::floating_point T>
bool geom::kdtree::KdTree< T >::ConstIterator::operator!= (
            const ConstIterator & lhs ) const
```

Definition at line 466 of file kdtree.hh.

5.5.4.7 beginFrom()

```
template<std::floating_point T>
KdTree< T >::ConstIterator geom::kdtree::KdTree< T >::ConstIterator::beginFrom (
            const ConstIterator & iter )  [static]
```

Definition at line 472 of file kdtree.hh.

Referenced by geom::kdtree::KdTree< T >::beginFrom().

The documentation for this class was generated from the following file:

- include/kdtree/kdtree.hh

5.6 geom::kdtree::KdTree< T >::ContainerPtr Struct Reference

`#include <kdtree.hh>`

Public Member Functions

- const Container< T > * operator-> () const

Public Attributes

- Container< T > cont

5.6.1 Detailed Description

template<std::floating_point T>
struct geom::kdtree::KdTree< T >::ContainerPtr

Definition at line 78 of file kdtree.hh.

5.6.2 Member Function Documentation

5.6.2.1 operator->()

```
template<std::floating_point T>
const Container< T > * geom::kdtree::KdTree< T >::ContainerPtr::operator->
```

Definition at line 404 of file kdtree.hh.

References geom::kdtree::KdTree< T >::ContainerPtr::cont.

5.6.3 Member Data Documentation

5.6.3.1 cont

```
template<std::floating_point T>
Container<T> geom::kdtree::KdTree< T >::ContainerPtr::cont
```

Definition at line 80 of file kdtree.hh.

Referenced by geom::kdtree::KdTree< T >::ContainerPtr::operator->().

The documentation for this struct was generated from the following file:

- include/kdtree/kdtree.hh

5.7 geom::kdtree::Node< T > Struct Template Reference

`#include <node.hh>`

Public Types

- using IndexIterator = std::vector< Index >::iterator
- using IndexConstIterator = std::vector< Index >::const_iterator

Public Member Functions

- void dumpRecursive (std::ostream &ost) const

Public Attributes

- T separator {}
- Axis sepAxis {Axis::NONE}
- BoundBox< T > boundBox {}
- std::vector< Index > indicies {}
- std::unique_ptr< Node > left {nullptr}
- std::unique_ptr< Node > right {nullptr}

5.7.1 Detailed Description

template<std::floating_point T>
struct geom::kdtree::Node< T >

Definition at line 16 of file node.hh.

5.7.2 Member Typedef Documentation

5.7.2.1 IndexIterator

```
template<std::floating_point T>
using geom::kdtree::Node< T >::IndexIterator = std::vector<Index>::iterator
```

Definition at line 26 of file node.hh.

5.7.2.2 IndexConstIterator

```
template<std::floating_point T>
using geom::kdtree::Node< T >::IndexConstIterator = std::vector<Index>::const_iterator
```

Definition at line 27 of file node.hh.

5.7.3 Member Function Documentation

5.7.3.1 dumpRecursive()

```
template<std::floating_point T>
void geom::kdtree::Node< T >::dumpRecursive (
            std::ostream & ost ) const
```

Definition at line 33 of file node.hh.

5.7.4 Member Data Documentation

5.7.4.1 separator

```
template<std::floating_point T>
T geom::kdtree::Node< T >::separator {}
```

Definition at line 18 of file node.hh.

5.7.4.2 sepAxis

```
template<std::floating_point T>
Axis geom::kdtree::Node< T >::sepAxis {Axis::NONE}
```

Definition at line 19 of file node.hh.

5.7.4.3 boundBox

```
template<std::floating_point T>
BoundBox<T> geom::kdtree::Node< T >::boundBox {}
```

Definition at line 20 of file node.hh.

5.7.4.4 indicies

```
template<std::floating_point T>
std::vector<Index> geom::kdtree::Node< T >::indicies {}
```

Definition at line 21 of file node.hh.

5.7.4.5 left

```
template<std::floating_point T>
std::unique_ptr<Node> geom::kdtree::Node< T >::left {nullptr}
```

Definition at line 23 of file node.hh.

5.7.4.6 right

```
template<std::floating_point T>
std::unique_ptr<Node> geom::kdtree::Node< T >::right {nullptr}
```

Definition at line 24 of file node.hh.

The documentation for this struct was generated from the following file:

- include/kdtree/node.hh

5.8 geom::Line< T > Class Template Reference

Line class implementation.

```
#include <line.hh>
```

Public Member Functions

- Line (const Vec3< T > &org, const Vec3< T > &dir)

  Construct a new Line object.
- bool operator== (const Line &rhs) const

  Line equality operator.
- bool operator!= (const Line &rhs) const

  Line inequality operator.
- const Vec3< T > & org () const &

  Getter for origin vector.
- const Vec3< T > & dir () const &

  Getter for direction vector.
- Vec3< T > && org () &&

  Getter for origin vector.
- Vec3< T > && dir () &&

  Getter for direction vector.
- template<Number nType>
  Vec3< T > getPoint (nType t) const

  Get point on line by parameter t.
- bool belongs (const Vec3< T > &point) const

  Checks is point belongs to line.
- bool isEqual (const Line &line) const

  Checks is ∗this equals to another line.
- bool isPar (const Line &line) const

  Checks is ∗this parallel to another line.
- bool isSkew (const Line< T > &line) const

  Checks is ∗this is skew with another line.

Static Public Member Functions

- static Line getBy2Points (const Vec3< T > &p1, const Vec3< T > &p2)

  Get line by 2 points.

5.8.1 Detailed Description

template<std::floating_point T>
class geom::Line< T >

Line class implementation.

Template Parameters

T	- floating point type of coordinates

Definition at line 21 of file line.hh.

5.8.2 Constructor & Destructor Documentation

5.8.2.1 Line()

```
template<std::floating_point T>
geom::Line< T >::Line (
            const Vec3< T > & org,
            const Vec3< T > & dir )
```

Construct a new Line object.

Parameters

in	*org*	origin vector
in	*dir*	direction vector

Definition at line 158 of file line.hh.

References geom::Line< T >::org().

5.8.3 Member Function Documentation

5.8.3.1 operator==()

```
template<std::floating_point T>
bool geom::Line< T >::operator== (
            const Line< T > & rhs ) const
```

Line equality operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in	*rhs*	2nd line

Returns

true if lines are equal

false if lines are not equal

Definition at line 165 of file line.hh.

5.8.3.2 operator"!=()

```
template<std::floating_point T>
bool geom::Line< T >::operator!= (
            const Line< T > & rhs ) const
```

Line inequality operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in	*rhs*	2nd line

Returns

true if lines are not equal

false if lines are equal

Definition at line 171 of file line.hh.

5.8.3.3 org() [1/2]

```
template<std::floating_point T>
Vec3< T > && geom::Line< T >::org
```

Getter for origin vector.

Returns

const Vec3<T>& const reference to origin vector

Definition at line 177 of file line.hh.

Referenced by geom::Plane< T >::belongs(), geom::detail::helperMollerHaines(), geom::intersect(), geom::Line< T >::Line(), and geom::operator<<().

5.8.3.4 dir() [1/2]

```
template<std::floating_point T>
Vec3< T > && geom::Line< T >::dir
```

Getter for direction vector.

Returns

const Vec3<T>& const reference to direction vector

Definition at line 183 of file line.hh.

Referenced by geom::Plane< T >::belongs(), geom::detail::helperMollerHaines(), geom::intersect(), and geom::operator<<().

5.8.3.5 org() [2/2]

```
template<std::floating_point T>
Vec3<T>&& geom::Line< T >::org ( ) &&
```

Getter for origin vector.

Returns

Vec3<T>&& reference to origin vector

5.8.3.6 dir() [2/2]

```
template<std::floating_point T>
Vec3<T>&& geom::Line< T >::dir ( ) &&
```

Getter for direction vector.

Returns

Vec3<T>&& reference to direction vector

5.8.3.7 getPoint()

```
template<std::floating_point T>
template<Number nType>
Vec3< T > geom::Line< T >::getPoint (
            nType t ) const
```

Get point on line by parameter t.

Template Parameters

nType	numeric type

Parameters

in	*t*	point paramater from line's equation

Returns

Vec3<T> Point related to parameter

Definition at line 202 of file line.hh.

Referenced by geom::intersect().

5.8.3.8 belongs()

```
template<std::floating_point T>
bool geom::Line< T >::belongs (
            const Vec3< T > & point ) const
```

Checks is point belongs to line.

Parameters

in	*point*	const reference to point vector

Returns

true if point belongs to line

false if point doesn't belong to line

Definition at line 208 of file line.hh.

5.8.3.9 isEqual()

```
template<std::floating_point T>
bool geom::Line< T >::isEqual (
            const Line< T > & line ) const
```

Checks is ∗this equals to another line.

Parameters

in	*line*	const reference to another line

Returns

true if lines are equal

false if lines are not equal

Definition at line 214 of file line.hh.

Referenced by geom::intersect().

5.8.3.10 isPar()

```
template<std::floating_point T>
bool geom::Line< T >::isPar (
            const Line< T > & line ) const
```

Checks is ∗this parallel to another line.

Note

Assumes equal lines as parallel

Parameters

in	*line*	const reference to another line

Returns

true if lines are parallel

false if lines are not parallel

Definition at line 220 of file line.hh.

Referenced by geom::intersect().

5.8.3.11 isSkew()

```
template<std::floating_point T>
bool geom::Line< T >::isSkew (
            const Line< T > & line ) const
```

Checks is ∗this is skew with another line.

Parameters

in	*line*	const reference to another line

Returns

true if lines are skew

false if lines are not skew

Definition at line 226 of file line.hh.

References geom::isZeroThreshold(), and geom::triple().

Referenced by geom::intersect().

5.8.3.12 getBy2Points()

```
template<std::floating_point T>
Line< T > geom::Line< T >::getBy2Points (
            const Vec3< T > & p1,
            const Vec3< T > & p2 )  [static]
```

Get line by 2 points.

Parameters

in	*p1*	1st point
in	*p2*	2nd point

Returns

Line passing through two points

Definition at line 233 of file line.hh.

The documentation for this class was generated from the following file:

- include/primitives/line.hh

5.9 geom::Plane< T > Class Template Reference

Plane class realization.

```
#include <plane.hh>
```

Public Member Functions

- bool operator== (const Plane &rhs) const

  Plane equality operator.
- bool operator!= (const Plane &rhs) const

  Plane inequality operator.
- T dist () const

  Getter for distance.
- const Vec3< T > & norm () const &

  Getter for normal vector.
- Vec3< T > && norm () &&

  Getter for normal vector.
- bool belongs (const Vec3< T > &point) const

  Checks if point belongs to plane.
- bool belongs (const Line< T > &line) const

  Checks if line belongs to plane.
- bool isEqual (const Plane &rhs) const

  Checks is ∗this equals to another plane.
- bool isPar (const Plane &rhs) const

  Checks is ∗this is parallel to another plane.

Static Public Member Functions

- static Plane getBy3Points (const Vec3< T > &pt1, const Vec3< T > &pt2, const Vec3< T > &pt3)

  Get plane by 3 points.
- static Plane getParametric (const Vec3< T > &org, const Vec3< T > &dir1, const Vec3< T > &dir2)

  Get plane from parametric plane equation.
- static Plane getNormalPoint (const Vec3< T > &norm, const Vec3< T > &point)

  Get plane from normal point plane equation.
- static Plane getNormalDist (const Vec3< T > &norm, T constant)

  Get plane form normal const plane equation.

5.9.1 Detailed Description

template<std::floating_point T>
class geom::Plane< T >

Plane class realization.

Template Parameters

T	- floating point type of coordinates

Definition at line 22 of file plane.hh.

5.9.2 Member Function Documentation

5.9.2.1 operator==()

```
template<std::floating_point T>
bool geom::Plane< T >::operator== (
            const Plane< T > & rhs ) const
```

Plane equality operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in	*rhs*	2nd plane

Returns

true if planes are equal

false if planes are not equal

Definition at line 183 of file plane.hh.

5.9.2.2 operator"!=()

```
template<std::floating_point T>
bool geom::Plane< T >::operator!= (
            const Plane< T > & rhs ) const
```

Plane inequality operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in	*rhs*	2nd plane

Returns

true if planes are not equal

false if planes are equal

Definition at line 189 of file plane.hh.

5.9.2.3 dist()

```
template<std::floating_point T>
T geom::Plane< T >::dist
```

Getter for distance.

Returns

T value of distance

Definition at line 195 of file plane.hh.

Referenced by geom::distance(), geom::intersect(), and geom::operator<<().

5.9.2.4 norm() [1/2]

```
template<std::floating_point T>
Vec3< T > && geom::Plane< T >::norm
```

Getter for normal vector.

Returns

const Vec3<T>& const reference to normal vector

Definition at line 201 of file plane.hh.

Referenced by geom::distance(), geom::detail::getTrian2(), geom::intersect(), and geom::operator<<().

5.9.2.5 norm() [2/2]

```
template<std::floating_point T>
Vec3<T>&& geom::Plane< T >::norm ( ) &&
```

Getter for normal vector.

Returns

Vec3<T>&& reference to normal vector

5.9.2.6 belongs() [1/2]

```
template<std::floating_point T>
bool geom::Plane< T >::belongs (
            const Vec3< T > & point ) const
```

Checks if point belongs to plane.

Parameters

in	*point*	const referene to point vector

Returns

true if point belongs to plane

false if point doesn't belong to plane

Definition at line 213 of file plane.hh.

References geom::isEqualThreshold().

5.9.2.7 belongs() [2/2]

```
template<std::floating_point T>
bool geom::Plane< T >::belongs (
            const Line< T > & line ) const
```

Checks if line belongs to plane.

Parameters

in	*line*	const referene to line

Returns

true if line belongs to plane

false if line doesn't belong to plane

Definition at line 219 of file plane.hh.

References geom::Line< T >::dir(), and geom::Line< T >::org().

5.9.2.8 isEqual()

```
template<std::floating_point T>
bool geom::Plane< T >::isEqual (
            const Plane< T > & rhs ) const
```

Checks is ∗this equals to another plane.

Parameters

in	*rhs*	const reference to another plane

Returns

true if planes are equal

false if planes are not equal

Definition at line 225 of file plane.hh.

5.9.2.9 isPar()

```
template<std::floating_point T>
bool geom::Plane< T >::isPar (
            const Plane< T > & rhs ) const
```

Checks is ∗this is parallel to another plane.

Parameters

in	*rhs*	const reference to another plane

Returns

true if planes are parallel

false if planes are not parallel

Definition at line 231 of file plane.hh.

References geom::Plane< T >::isPar().

Referenced by geom::Plane< T >::isPar().

5.9.2.10 getBy3Points()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getBy3Points (
            const Vec3< T > & pt1,
            const Vec3< T > & pt2,
            const Vec3< T > & pt3 )  [static]
```

Get plane by 3 points.

Parameters

in	*pt1*	1st point
in	*pt2*	2nd point
in	*pt3*	3rd point

Returns

Plane passing through three points

Definition at line 237 of file plane.hh.

Referenced by geom::Triangle< T >::getPlane().

5.9.2.11 getParametric()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getParametric (
            const Vec3< T > & org,
            const Vec3< T > & dir1,
            const Vec3< T > & dir2 )  [static]
```

Get plane from parametric plane equation.

Parameters

in	*org*	origin vector
in	*dir1*	1st direction vector
in	*dir2*	2nd direction vector

Returns

Plane

Definition at line 243 of file plane.hh.

References geom::Vec3< T >::cross().

5.9.2.12 getNormalPoint()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getNormalPoint (
            const Vec3< T > & norm,
            const Vec3< T > & point )  [static]
```

Get plane from normal point plane equation.

Parameters

in	*norm*	normal vector
in	*point*	point lying on the plane

Returns

Plane

Definition at line 250 of file plane.hh.

References geom::Vec3< T >::normalized().

5.9.2.13 getNormalDist()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getNormalDist (
            const Vec3< T > & norm,
            T constant )  [static]
```

Get plane form normal const plane equation.

Parameters

in	*norm*	normal vector
in	*constant*	distance

Returns

Plane

Definition at line 257 of file plane.hh.

References geom::Vec3< T >::normalized().

The documentation for this class was generated from the following file:

- include/primitives/plane.hh

5.10 geom::ThresComp< T > Class Template Reference

`#include <common.hh>`

Public Member Functions

- ThresComp ()=delete

Static Public Member Functions

- static void setThreshold (T thres) requires std
- static bool isZero (T num)

5.10.1 Detailed Description

template<Number T>
class geom::ThresComp< T >

Definition at line 28 of file common.hh.

5.10.2 Constructor & Destructor Documentation

5.10.2.1 ThresComp()

```
template<Number T>
geom::ThresComp< T >::ThresComp ( )  [delete]
```

5.10.3 Member Function Documentation

5.10.3.1 setThreshold()

```
template<Number T>
static void geom::ThresComp< T >::setThreshold (
            T thres )  [inline], [static]
```

Definition at line 36 of file common.hh.

5.10.3.2 isZero()

```
template<Number T>
static bool geom::ThresComp< T >::isZero (
            T num )  [inline], [static]
```

Definition at line 64 of file common.hh.

Referenced by geom::isZeroThreshold().

The documentation for this class was generated from the following file:

- include/primitives/common.hh

5.11 geom::Triangle< T > Class Template Reference

Triangle class implementation.

`#include <triangle.hh>`

Public Types

- using Iterator = typename std::array< Vec3< T >, 3 >::iterator
- using ConstIterator = typename std::array< Vec3< T >, 3 >::const_iterator

Public Member Functions

- Triangle ()

  Construct a new Triangle object.
- Triangle (const Vec3< T > &p1, const Vec3< T > &p2, const Vec3< T > &p3)

  Construct a new Triangle object from 3 points.
- const Vec3< T > & operator[ ] (std::size_t idx) const &

  Overloaded operator[] to get access to vertices.
- Vec3< T > && operator[ ] (std::size_t idx) &&

  Overloaded operator[] to get access to vertices.
- Vec3< T > & operator[ ] (std::size_t idx) &

  Overloaded operator[] to get access to vertices.
- Iterator begin () &

  Get begin iterator.
- Iterator end () &

  Get end iterator.
- ConstIterator begin () const &

  Get begin const iterator.
- ConstIterator end () const &

  Get end const iterator.
- Plane< T > getPlane () const

  Get triangle's plane.
- bool isValid () const

  Check is triangle valid.
- BoundBox< T > boundBox () const

  Returns triangle's bound box.
- bool belongsTo (const BoundBox< T > &bb) const

  Checks if this Triangle belongs to BoundBox.

5.11.1 Detailed Description

template<std::floating_point T>
class geom::Triangle< T >

Triangle class implementation.

Template Parameters

T	- floating point type of coordinates

Definition at line 26 of file triangle.hh.

5.11.2 Member Typedef Documentation

5.11.2.1 Iterator

```
template<std::floating_point T>
using geom::Triangle< T >::Iterator = typename std::array<Vec3<T>, 3>::iterator
```

Definition at line 35 of file triangle.hh.

5.11.2.2 ConstIterator

```
template<std::floating_point T>
using geom::Triangle< T >::ConstIterator = typename std::array<Vec3<T>, 3>::const_iterator
```

Definition at line 36 of file triangle.hh.

5.11.3 Constructor & Destructor Documentation

5.11.3.1 Triangle() [1/2]

```
template<std::floating_point T>
geom::Triangle< T >::Triangle
```

Construct a new Triangle object.

Definition at line 160 of file triangle.hh.

5.11.3.2 Triangle() [2/2]

```
template<std::floating_point T>
geom::Triangle< T >::Triangle (
            const Vec3< T > & p1,
            const Vec3< T > & p2,
            const Vec3< T > & p3 )
```

Construct a new Triangle object from 3 points.

Parameters

in	*p1*	1st point
in	*p2*	2nd point
in	*p3*	3rd point

Definition at line 164 of file triangle.hh.

5.11.4 Member Function Documentation

5.11.4.1 operator[]() [1/3]

```
template<std::floating_point T>
const Vec3< T > & geom::Triangle< T >::operator[] (
            std::size_t idx ) const &
```

Overloaded operator[] to get access to vertices.

Parameters

in	*idx*	index of vertex

Returns

const Vec3<T>& const reference to vertex

Definition at line 169 of file triangle.hh.

5.11.4.2 operator[]() [2/3]

```
template<std::floating_point T>
Vec3< T > && geom::Triangle< T >::operator[] (
            std::size_t idx ) &&
```

Overloaded operator[] to get access to vertices.

Parameters

in	*idx*	index of vertex

Returns

Vec3<T>&& reference to vertex

Definition at line 175 of file triangle.hh.

5.11.4.3 operator[]() [3/3]

```
template<std::floating_point T>
Vec3< T > & geom::Triangle< T >::operator[] (
            std::size_t idx ) &
```

Overloaded operator[] to get access to vertices.

Parameters

in	*idx*	index of vertex

Returns

Vec3<T>& reference to vertex

Definition at line 181 of file triangle.hh.

5.11.4.4 begin() [1/2]

```
template<std::floating_point T>
Triangle< T >::ConstIterator geom::Triangle< T >::begin
```

Get begin iterator.

Returns

Iterator

Definition at line 187 of file triangle.hh.

Referenced by geom::detail::helperMollerHaines(), geom::detail::isOnOneSide(), and geom::kdtree::KdTree< T >::isOnSide().

5.11.4.5 end() [1/2]

```
template<std::floating_point T>
Triangle< T >::ConstIterator geom::Triangle< T >::end
```

Get end iterator.

Returns

Iterator

Definition at line 193 of file triangle.hh.

Referenced by geom::detail::helperMollerHaines(), geom::detail::isOnOneSide(), and geom::kdtree::KdTree< T >::isOnSide().

5.11.4.6 begin() [2/2]

```
template<std::floating_point T>
ConstIterator geom::Triangle< T >::begin ( ) const &
```

Get begin const iterator.

Returns

ConstIterator

5.11.4.7 end() [2/2]

```
template<std::floating_point T>
ConstIterator geom::Triangle< T >::end ( ) const &
```

Get end const iterator.

Returns

ConstIterator

5.11.4.8 getPlane()

```
template<std::floating_point T>
Plane< T > geom::Triangle< T >::getPlane
```

Get triangle's plane.

Returns

Plane<T>

Definition at line 211 of file triangle.hh.

References geom::Plane< T >::getBy3Points().

Referenced by geom::isIntersect(), geom::detail::isIntersect2D(), geom::detail::isIntersectMollerHaines(), geom::detail::isIntersectPointTriangle(), and geom::detail::isIntersectValidInvalid().

5.11.4.9 isValid()

```
template<std::floating_point T>
bool geom::Triangle< T >::isValid
```

Check is triangle valid.

Returns

true if triangle is valid

false if triangle is invalid

Definition at line 217 of file triangle.hh.

References geom::cross().

Referenced by geom::isIntersect().

5.11.4.10 boundBox()

```
template<std::floating_point T>
BoundBox< T > geom::Triangle< T >::boundBox
```

Returns triangle's bound box.

Returns

BoundBox<T>

Definition at line 227 of file triangle.hh.

Referenced by geom::kdtree::KdTree< T >::insert().

5.11.4.11 belongsTo()

```
template<std::floating_point T>
bool geom::Triangle< T >::belongsTo (
            const BoundBox< T > & bb ) const
```

Checks if this Triangle belongs to BoundBox.

Parameters

in	*bb*	BoundBox

Returns

true if Triangle belongs to BoundBox

false if Triangle doesn't belong to BoundBox

Definition at line 240 of file triangle.hh.

Referenced by geom::kdtree::KdTree< T >::insert().

The documentation for this class was generated from the following file:

- include/primitives/triangle.hh

5.12 geom::Vec2< T > Class Template Reference

Vec2 class realization.

`#include <vec2.hh>`

Public Member Functions

- Vec2 (T coordX, T coordY)

  Construct a new Vec2 object from 3 coordinates.
- Vec2 (T coordX={})

  Construct a new Vec2 object with equals coordinates.
- bool operator== (const Vec2 &rhs) const

  Vec2 equality operator.
- bool operator!= (const Vec2 &rhs) const

  Vec2 equality operator.
- Vec2 & operator+= (const Vec2 &vec)

  Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.
- Vec2 & operator-= (const Vec2 &vec)

  Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.
- Vec2 operator- () const

  Unary - operator.
- template<Number nType>
  Vec2 & operator*= (nType val)

  *Overloaded *= by number operator.*
- template<Number nType>
  Vec2 & operator/= (nType val)

  Overloaded /= by number operator.
- T dot (const Vec2 &rhs) const

  Dot product function.
- T length2 () const

  Calculate squared length of a vector function.
- T length () const

  Calculate length of a vector function.
- Vec2 getPerp () const

  Get the perpendicular to this vector.
- Vec2 normalized () const

Get normalized vector function.

- Vec2 & normalize () &

  Normalize vector function.

- T & operator[ ] (std::size_t i) &

  Overloaded operator [] (non-const version) To get access to coordinates.

- T operator[ ] (std::size_t i) const &

  Overloaded operator [] (const version) To get access to coordinates.

- T && operator[ ] (std::size_t i) &&

  Overloaded operator [] (const version) To get access to coordinates.

- bool isPar (const Vec2 &rhs) const

  Check if vector is parallel to another.

- bool isPerp (const Vec2 &rhs) const

  Check if vector is perpendicular to another.

- bool isEqual (const Vec2 &rhs) const

  Check if vector is equal to another.

- template<Number nType>
  Vec2< T > & operator*= (nType val)
- template<Number nType>
  Vec2< T > & operator/= (nType val)

Public Attributes

- T x {}

  Vec2 coordinates.

- T y {}

5.12.1 Detailed Description

template<std::floating_point T>
class geom::Vec2< T >

Vec2 class realization.

Template Parameters

T	- floating point type of coordinates

Definition at line 26 of file vec2.hh.

5.12.2 Constructor & Destructor Documentation

5.12.2.1 Vec2() [1/2]

```
template<std::floating_point T>
geom::Vec2< T >::Vec2 (
```

```
            T coordX,
            T coordY )  [inline]
```

Construct a new Vec2 object from 3 coordinates.

Parameters

in	*coordX*	x coordinate
in	*coordY*	y coordinate

Definition at line 39 of file vec2.hh.

5.12.2.2 Vec2() [2/2]

```
template<std::floating_point T>
geom::Vec2< T >::Vec2 (
            T coordX = {} )  [inline], [explicit]
```

Construct a new Vec2 object with equals coordinates.

Parameters

in	*coordX*	coordinate (default to {})

Definition at line 47 of file vec2.hh.

5.12.3 Member Function Documentation

5.12.3.1 operator==()

```
template<std::floating_point T>
bool geom::Vec2< T >::operator== (
            const Vec2< T > & rhs ) const
```

Vec2 equality operator.

Template Parameters

T	vector template parameter

Parameters

in	*rhs*	second vector

Returns

true if vectors are equal

false otherwise

Definition at line 332 of file vec2.hh.

5.12.3.2 operator"!=()

```
template<std::floating_point T>
bool geom::Vec2< T >::operator!= (
            const Vec2< T > & rhs ) const
```

Vec2 equality operator.

Template Parameters

T	vector template parameter

Parameters

in	*rhs*	second vector

Returns

true if vectors are not equal

false otherwise

Definition at line 338 of file vec2.hh.

5.12.3.3 operator+=()

```
template<std::floating_point T>
Vec2< T > & geom::Vec2< T >::operator+= (
            const Vec2< T > & vec )
```

Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.

Parameters

in	*vec*	vector to incremented with

Returns

Vec2& reference to current instance

Definition at line 344 of file vec2.hh.

References geom::Vec2< T >::x, and geom::Vec2< T >::y.

5.12.3.4 operator-=()

```
template<std::floating_point T>
Vec2< T > & geom::Vec2< T >::operator-= (
            const Vec2< T > & vec )
```

Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.

Parameters

in	*vec*	vector to decremented with

Returns

Vec2& reference to current instance

Definition at line 353 of file vec2.hh.

References geom::Vec2< T >::x, and geom::Vec2< T >::y.

5.12.3.5 operator-()

```
template<std::floating_point T>
Vec2< T > geom::Vec2< T >::operator-
```

Unary - operator.

Returns

Vec2 negated Vec2 instance

Definition at line 362 of file vec2.hh.

5.12.3.6 operator*=() [1/2]

```
template<std::floating_point T>
template<Number nType>
Vec2& geom::Vec2< T >::operator*= (
            nType val )
```

Overloaded *= by number operator.

Template Parameters

nType	numeric type of value to multiply by

Parameters

in	*val*	value to multiply by

Returns

Vec2& reference to vector instance

5.12.3.7 operator/=() [1/2]

```
template<std::floating_point T>
template<Number nType>
Vec2& geom::Vec2< T >::operator/= (
            nType val )
```

Overloaded /= by number operator.

Template Parameters

nType	numeric type of value to divide by

Parameters

in	*val*	value to divide by

Returns

Vec2& reference to vector instance

Warning

Does not check if val equals 0

5.12.3.8 dot()

```
template<std::floating_point T>
T geom::Vec2< T >::dot (
            const Vec2< T > & rhs ) const
```

Dot product function.

Parameters

rhs	vector to dot product with

Returns

T dot product of two vectors

Definition at line 388 of file vec2.hh.

References geom::Vec2< T >::x, and geom::Vec2< T >::y.

Referenced by geom::dot().

5.12.3.9 length2()

```
template<std::floating_point T>
T geom::Vec2< T >::length2
```

Calculate squared length of a vector function.

Returns

T length^2

Definition at line 394 of file vec2.hh.

References geom::dot().

5.12.3.10 length()

```
template<std::floating_point T>
T geom::Vec2< T >::length
```

Calculate length of a vector function.

Returns

T length

Definition at line 400 of file vec2.hh.

5.12.3.11 getPerp()

```
template<std::floating_point T>
Vec2< T > geom::Vec2< T >::getPerp
```

Get the perpendicular to this vector.

Returns

Vec2 perpendicular vector

Definition at line 406 of file vec2.hh.

5.12.3.12 normalized()

```
template<std::floating_point T>
Vec2< T > geom::Vec2< T >::normalized
```

Get normalized vector function.

Returns

Vec2 normalized vector

Definition at line 412 of file vec2.hh.

References geom::Vec2< T >::normalize().

5.12.3.13 normalize()

```
template<std::floating_point T>
Vec2< T > & geom::Vec2< T >::normalize
```

Normalize vector function.

Returns

Vec2& reference to instance

Definition at line 420 of file vec2.hh.

References geom::isEqualThreshold(), and geom::isZeroThreshold().

Referenced by geom::Vec2< T >::normalized().

5.12.3.14 operator[]() [1/3]

```
template<std::floating_point T>
T & geom::Vec2< T >::operator[] (
            std::size_t i ) &
```

Overloaded operator [] (non-const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y)

Returns

T& reference to coordinate value

Note

Coordinates calculated by mod 2

Definition at line 429 of file vec2.hh.

5.12.3.15 operator[]() [2/3]

```
template<std::floating_point T>
T geom::Vec2< T >::operator[] (
            std::size_t i ) const &
```

Overloaded operator [] (const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y)

Returns

T coordinate value

Note

Coordinates calculated by mod 2

Definition at line 443 of file vec2.hh.

5.12.3.16 operator[]() [3/3]

```
template<std::floating_point T>
T && geom::Vec2< T >::operator[] (
            std::size_t i ) &&
```

Overloaded operator [] (const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y)

Returns

T coordinate value

Note

Coordinates calculated by mod 2

Definition at line 457 of file vec2.hh.

5.12.3.17 isPar()

```
template<std::floating_point T>
bool geom::Vec2< T >::isPar (
            const Vec2< T > & rhs ) const
```

Check if vector is parallel to another.

Parameters

in	*rhs*	vector to check parallelism with

Returns

true if vector is parallel

false otherwise

Definition at line 471 of file vec2.hh.

References geom::isZeroThreshold(), geom::Vec2< T >::x, and geom::Vec2< T >::y.

5.12.3.18 isPerp()

```
template<std::floating_point T>
bool geom::Vec2< T >::isPerp (
            const Vec2< T > & rhs ) const
```

Check if vector is perpendicular to another.

Parameters

in	*rhs*	vector to check perpendicularity with

Returns

true if vector is perpendicular

false otherwise

Definition at line 478 of file vec2.hh.

References geom::dot(), and geom::isZeroThreshold().

5.12.3.19 isEqual()

```
template<std::floating_point T>
bool geom::Vec2< T >::isEqual (
            const Vec2< T > & rhs ) const
```

Check if vector is equal to another.

Parameters

in	*rhs*	vector to check equality with

Returns

true if vector is equal

false otherwise

Definition at line 484 of file vec2.hh.

References geom::isEqualThreshold(), geom::Vec2< T >::x, and geom::Vec2< T >::y.

5.12.3.20 operator*=() [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec2<T>& geom::Vec2< T >::operator*= (
            nType val )
```

Definition at line 369 of file vec2.hh.

5.12.3.21 operator/=() [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec2<T>& geom::Vec2< T >::operator/= (
            nType val )
```

Definition at line 379 of file vec2.hh.

5.12.4 Member Data Documentation

5.12.4.1 x

```
template<std::floating_point T>
T geom::Vec2< T >::x {}
```

Vec2 coordinates.

Definition at line 31 of file vec2.hh.

Referenced by geom::Vec2< T >::dot(), geom::Vec2< T >::isEqual(), geom::Vec2< T >::isPar(), geom::Vec2< T >::operator+=(), geom::Vec2< T >::operator-=(), and geom::operator<<().

5.12.4.2 y

```
template<std::floating_point T>
T geom::Vec2< T >::y {}
```

Definition at line 31 of file vec2.hh.

Referenced by geom::Vec2< T >::dot(), geom::Vec2< T >::isEqual(), geom::Vec2< T >::isPar(), geom::Vec2< T >::operator+=(), geom::Vec2< T >::operator-=(), and geom::operator<<().

The documentation for this class was generated from the following file:

- include/primitives/vec2.hh

5.13 geom::Vec3< T > Class Template Reference

Vec3 class realization.

```
#include <vec3.hh>
```

Public Member Functions

- Vec3 (T coordX, T coordY, T coordZ)

  Construct a new Vec3 object from 3 coordinates.
- Vec3 (T coordX={})

  Construct a new Vec3 object with equals coordinates.
- bool operator== (const Vec3 &rhs) const

  Vec3 equality operator.
- bool operator!= (const Vec3 &rhs) const

  Vec3 inequality operator.
- Vec3 & operator+= (const Vec3 &vec)

  Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.
- Vec3 & operator-= (const Vec3 &vec)

  Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.
- Vec3 operator- () const

  Unary - operator.
- template<Number nType>
  Vec3 & operator*= (nType val)

  *Overloaded *= by number operator.*
- template<Number nType>
  Vec3 & operator/= (nType val)

  Overloaded /= by number operator.
- T dot (const Vec3 &rhs) const

  Dot product function.
- Vec3 cross (const Vec3 &rhs) const

  Cross product function.
- T length2 () const

  Calculate squared length of a vector function.
- T length () const

  Calculate length of a vector function.
- Vec3 normalized () const

  Get normalized vector function.
- Vec3 & normalize () &

  Normalize vector function.
- T & operator[ ] (std::size_t i) &

  Overloaded operator [] (non-const version) To get access to coordinates.
- T operator[ ] (std::size_t i) const &

  Overloaded operator [] (const version) To get access to coordinates.
- T && operator[ ] (std::size_t i) &&

  Overloaded operator [] (rvalue `this` version) To get access to coordinates.
- bool isPar (const Vec3 &rhs) const

  Check if vector is parallel to another.
- bool isPerp (const Vec3 &rhs) const

  Check if vector is perpendicular to another.
- bool isEqual (const Vec3 &rhs) const

  Check if vector is equal to another.
- template<Number nType>
  Vec3< T > & operator*= (nType val)
- template<Number nType>
  Vec3< T > & operator/= (nType val)

Public Attributes

- T x {}

  Vec3 coordinates.
- T y {}
- T z {}

5.13.1 Detailed Description

template<std::floating_point T>
class geom::Vec3< T >

Vec3 class realization.

Template Parameters

T	- floating point type of coordinates

Definition at line 26 of file vec3.hh.

5.13.2 Constructor & Destructor Documentation

5.13.2.1 Vec3() [1/2]

```
template<std::floating_point T>
geom::Vec3< T >::Vec3 (
            T coordX,
            T coordY,
            T coordZ )  [inline]
```

Construct a new Vec3 object from 3 coordinates.

Parameters

in	*coordX*	x coordinate
in	*coordY*	y coordinate
in	*coordZ*	z coordinate

Definition at line 40 of file vec3.hh.

5.13.2.2 Vec3() [2/2]

```
template<std::floating_point T>
geom::Vec3< T >::Vec3 (
            T coordX = {} )  [inline], [explicit]
```

Construct a new Vec3 object with equals coordinates.

Parameters

in	*coordX*	coordinate (default to {})

Definition at line 48 of file vec3.hh.

5.13.3 Member Function Documentation

5.13.3.1 operator==()

```
template<std::floating_point T>
bool geom::Vec3< T >::operator== (
            const Vec3< T > & rhs ) const
```

Vec3 equality operator.

Template Parameters

T	vector template parameter

Parameters

in	*rhs*	second vector

Returns

true if vectors are equal

false otherwise

Definition at line 378 of file vec3.hh.

5.13.3.2 operator"!=()

```
template<std::floating_point T>
bool geom::Vec3< T >::operator!= (
            const Vec3< T > & rhs ) const
```

Vec3 inequality operator.

Template Parameters

T	vector template parameter

Parameters

in	*rhs*	second vector

Returns

true if vectors are not equal

false otherwise

Definition at line 384 of file vec3.hh.

5.13.3.3 operator+=()

```
template<std::floating_point T>
Vec3< T > & geom::Vec3< T >::operator+= (
            const Vec3< T > & vec )
```

Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.

Parameters

in	*vec*	vector to incremented with

Returns

Vec3& reference to current instance

Definition at line 390 of file vec3.hh.

References geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

5.13.3.4 operator-=()

```
template<std::floating_point T>
Vec3< T > & geom::Vec3< T >::operator-= (
            const Vec3< T > & vec )
```

Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.

Parameters

in	*vec*	vector to decremented with

Returns

Vec3& reference to current instance

Definition at line 400 of file vec3.hh.

References geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

5.13.3.5 operator-()

```
template<std::floating_point T>
Vec3< T > geom::Vec3< T >::operator-
```

Unary - operator.

Returns

Vec3 negated Vec3 instance

Definition at line 410 of file vec3.hh.

5.13.3.6 operator*=() [1/2]

```
template<std::floating_point T>
template<Number nType>
Vec3& geom::Vec3< T >::operator*= (
            nType val )
```

Overloaded *= by number operator.

Template Parameters

nType	numeric type of value to multiply by

Parameters

in	*val*	value to multiply by

Returns

Vec3& reference to vector instance

5.13.3.7 operator/=() [1/2]

```
template<std::floating_point T>
template<Number nType>
Vec3& geom::Vec3< T >::operator/= (
            nType val )
```

Overloaded /= by number operator.

Template Parameters

nType	numeric type of value to divide by

Parameters

in	*val*	value to divide by

Returns

Vec3& reference to vector instance

Warning

Does not check if val equals 0

5.13.3.8 dot()

```
template<std::floating_point T>
T geom::Vec3< T >::dot (
            const Vec3< T > & rhs ) const
```

Dot product function.

Parameters

rhs	vector to dot product with

Returns

T dot product of two vectors

Definition at line 440 of file vec3.hh.

References geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

Referenced by geom::dot().

5.13.3.9 cross()

```
template<std::floating_point T>
Vec3< T > geom::Vec3< T >::cross (
            const Vec3< T > & rhs ) const
```

Cross product function.

Parameters

rhs	vector to cross product with

Returns

Vec3 cross product of two vectors

Definition at line 446 of file vec3.hh.

References geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

Referenced by geom::cross(), and geom::Plane< T >::getParametric().

5.13.3.10 length2()

```
template<std::floating_point T>
T geom::Vec3< T >::length2
```

Calculate squared length of a vector function.

Returns

T length^2

Definition at line 452 of file vec3.hh.

References geom::dot().

5.13.3.11 length()

```
template<std::floating_point T>
T geom::Vec3< T >::length
```

Calculate length of a vector function.

Returns

T length

Definition at line 458 of file vec3.hh.

5.13.3.12 normalized()

```
template<std::floating_point T>
Vec3< T > geom::Vec3< T >::normalized
```

Get normalized vector function.

Returns

Vec3 normalized vector

Definition at line 464 of file vec3.hh.

References geom::Vec3< T >::normalize().

Referenced by geom::Plane< T >::getNormalDist(), and geom::Plane< T >::getNormalPoint().

5.13.3.13 normalize()

```
template<std::floating_point T>
Vec3< T > & geom::Vec3< T >::normalize
```

Normalize vector function.

Returns

Vec3& reference to instance

Definition at line 472 of file vec3.hh.

References geom::isEqualThreshold(), and geom::isZeroThreshold().

Referenced by geom::Vec3< T >::normalized().

5.13.3.14 operator[]() [1/3]

```
template<std::floating_point T>
T & geom::Vec3< T >::operator[] (
            std::size_t i ) &
```

Overloaded operator [] (non-const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y, 2 - z)

Returns

T& reference to coordinate value

Note

Coordinates calculated by mod 3

Definition at line 481 of file vec3.hh.

5.13.3.15 operator[]() [2/3]

```
template<std::floating_point T>
T geom::Vec3< T >::operator[] (
            std::size_t i ) const &
```

Overloaded operator [] (const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y, 2 - z)

Returns

T coordinate value

Note

Coordinates calculated by mod 3

Definition at line 497 of file vec3.hh.

5.13.3.16 operator[]() [3/3]

```
template<std::floating_point T>
T && geom::Vec3< T >::operator[] (
            std::size_t i ) &&
```

Overloaded operator [] (rvalue `this` version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y, 2 - z)

Returns

T coordinate value

Note

Coordinates calculated by mod 3

Definition at line 513 of file vec3.hh.

5.13.3.17 isPar()

```
template<std::floating_point T>
bool geom::Vec3< T >::isPar (
            const Vec3< T > & rhs ) const
```

Check if vector is parallel to another.

Parameters

in	*rhs*	vector to check parallelism with

Returns

true if vector is parallel

false otherwise

Definition at line 529 of file vec3.hh.

References geom::cross().

5.13.3.18 isPerp()

```
template<std::floating_point T>
bool geom::Vec3< T >::isPerp (
            const Vec3< T > & rhs ) const
```

Check if vector is perpendicular to another.

Parameters

in	*rhs*	vector to check perpendicularity with

Returns

true if vector is perpendicular

false otherwise

Definition at line 535 of file vec3.hh.

References geom::dot(), and geom::isZeroThreshold().

5.13.3.19 isEqual()

```
template<std::floating_point T>
bool geom::Vec3< T >::isEqual (
            const Vec3< T > & rhs ) const
```

Check if vector is equal to another.

Parameters

in	*rhs*	vector to check equality with

Returns

true if vector is equal

false otherwise

Definition at line 541 of file vec3.hh.

References geom::isEqualThreshold(), geom::Vec3< T >::x, geom::Vec3< T >::y, and geom::Vec3< T >::z.

5.13.3.20 operator*=() [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec3<T>& geom::Vec3< T >::operator*= (
            nType val )
```

Definition at line 417 of file vec3.hh.

5.13.3.21 operator/=() [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec3<T>& geom::Vec3< T >::operator/= (
            nType val )
```

Definition at line 429 of file vec3.hh.

5.13.4 Member Data Documentation

5.13.4.1 x

```
template<std::floating_point T>
T geom::Vec3< T >::x {}
```

Vec3 coordinates.

Definition at line 31 of file vec3.hh.

Referenced by geom::Vec3< T >::cross(), geom::Vec3< T >::dot(), geom::Vec3< T >::isEqual(), geom::Vec3< T >::operator+=(), geom::Vec3< T >::operator-=(), geom::operator<<(), and geom::operator>>().

5.13.4.2 y

```
template<std::floating_point T>
T geom::Vec3< T >::y {}
```

Definition at line 31 of file vec3.hh.

Referenced by geom::Vec3< T >::cross(), geom::Vec3< T >::dot(), geom::Vec3< T >::isEqual(), geom::Vec3< T >::operator+=(), geom::Vec3< T >::operator-=(), geom::operator<<(), and geom::operator>>().

5.13.4.3 z

```
template<std::floating_point T>
T geom::Vec3< T >::z {}
```

Definition at line 31 of file vec3.hh.

Referenced by geom::Vec3< T >::cross(), geom::Vec3< T >::dot(), geom::Vec3< T >::isEqual(), geom::Vec3< T >::operator+=(), geom::Vec3< T >::operator-=(), geom::operator<<(), and geom::operator>>().

The documentation for this class was generated from the following file:

- include/primitives/vec3.hh

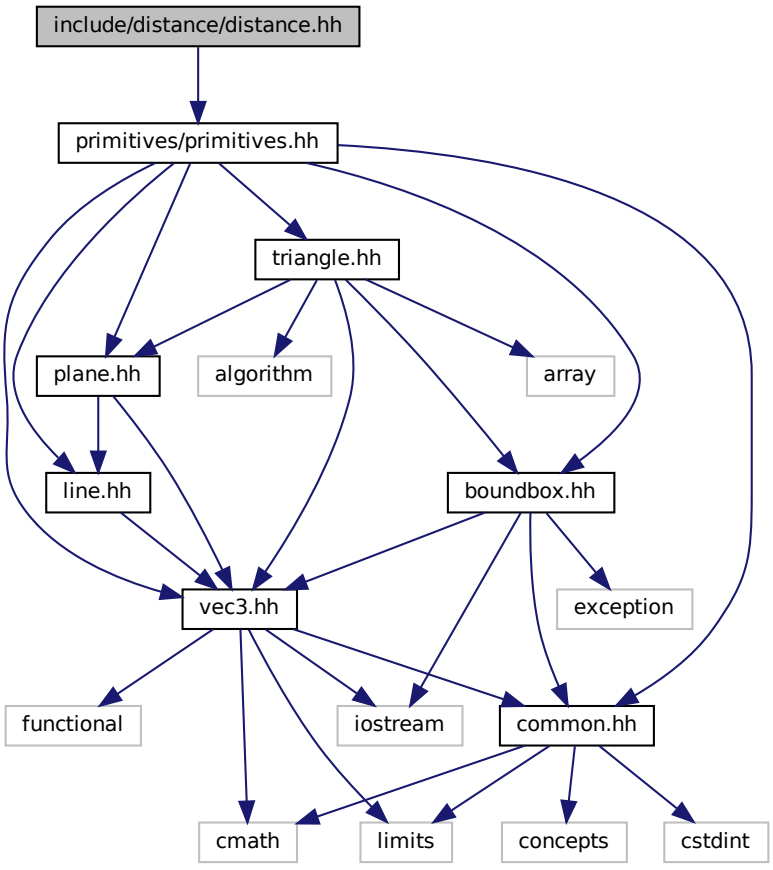
Chapter 6

File Documentation

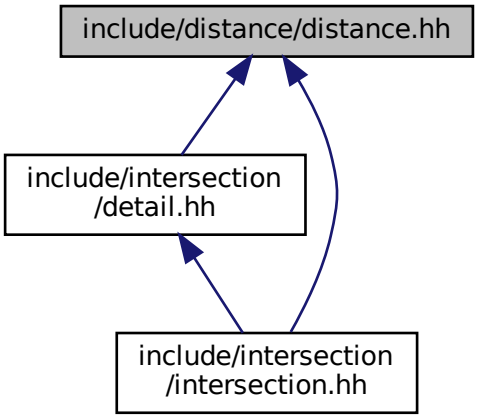
6.1 include/distance/distance.hh File Reference

```
#include "primitives/primitives.hh"
```

Include dependency graph for distance.hh:



This graph shows which files directly or indirectly include this file:



Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  T geom::distance (const Plane< T > &pl, const Vec3< T > &pt)

  Calculates signed distance between point and plane.

6.2 distance.hh

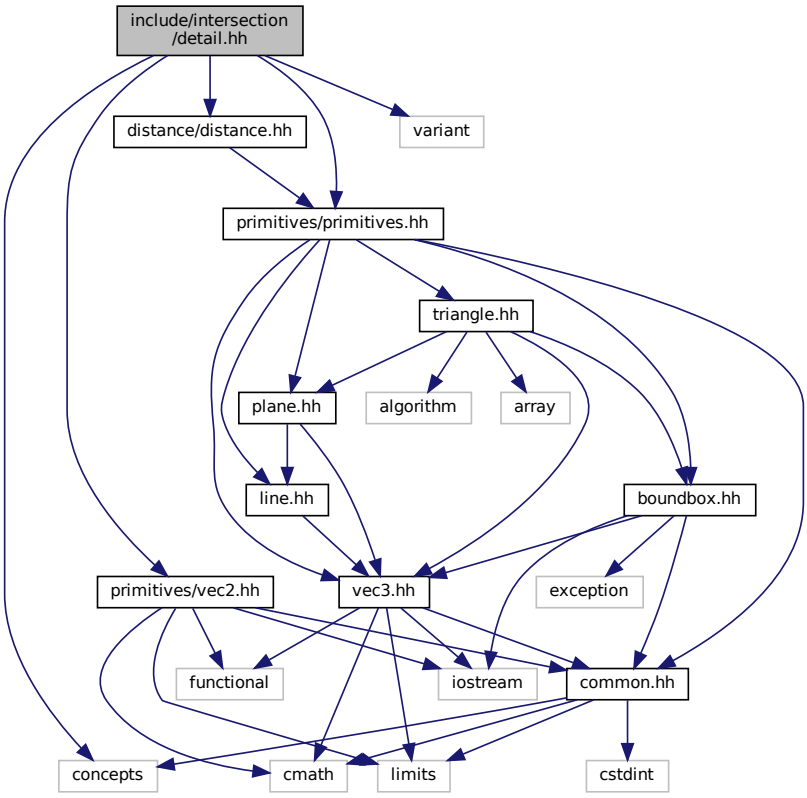
```
00001 #ifndef __INCLUDE_DISTANCE_DISTANCE_HH__
00002 #define __INCLUDE_DISTANCE_DISTANCE_HH__
00003
00004 #include "primitives/primitives.hh"
00005
00006 namespace geom
00007 {
00008
00009 /**
00010  * @brief Calculates signed distance between point and plane
00011  *
00012  * @tparam T - floating point type of coordinates
00013  * @param pl plane
00014  * @param pt point
00015  * @return T signed distance between point and plane
00016  */
00017 template <std::floating_point T>
00018 T distance(const Plane<T> &pl, const Vec3<T> &pt);
00019
00020 } // namespace geom
00021
00022 namespace geom
00023 {
00024
00025 template <std::floating_point T>
```

```
00026 T distance(const Plane<T> &pl, const Vec3<T> &pt)
00027 {
00028   return dot(pt, pl.norm()) - pl.dist();
00029 }
00030
00031 } // namespace geom
00032
00033 #endif // __INCLUDE_DISTANCE_DISTANCE_HH__
```

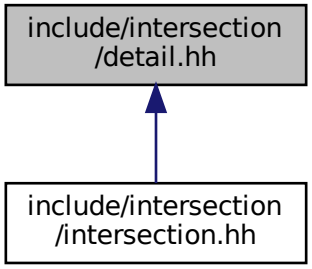
6.3 include/intersection/detail.hh File Reference

```
#include <concepts>
#include <variant>
#include "distance/distance.hh"
#include "primitives/primitives.hh"
#include "primitives/vec2.hh"
```

Include dependency graph for detail.hh:



This graph shows which files directly or indirectly include this file:



Namespaces

- geom
  line.hh Line class implementation
- geom::detail

Typedefs

- template<typename T >
  using geom::detail::Segment2D = std::pair< T, T >
- template<std::floating_point T>
  using geom::detail::Trian2 = std::array< Vec2< T >, 3 >
- template<std::floating_point T>
  using geom::detail::Segment3D = std::pair< Vec3< T >, Vec3< T > >

Functions

- template<std::floating_point T>
  bool geom::detail::isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  bool geom::detail::isIntersectMollerHaines (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  Segment2D< T > geom::detail::helperMollerHaines (const Triangle< T > &tr, const Plane< T > &pl, const Line< T > &l)
- template<std::floating_point T>
  bool geom::detail::isIntersectBothInvalid (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  bool geom::detail::isIntersectValidInvalid (const Triangle< T > &valid, const Triangle< T > &invalid)
- template<std::floating_point T>
  bool geom::detail::isIntersectPointTriangle (const Vec3< T > &pt, const Triangle< T > &tr)
- template<std::floating_point T>
  bool geom::detail::isIntersectPointSegment (const Vec3< T > &pt, const Segment3D< T > &segm)
- template<std::floating_point T>
  bool geom::detail::isIntersectSegmentSegment (const Segment3D< T > &segm1, const Segment3D< T > &segm2)

- template<std::floating_point T>
  bool geom::detail::isPoint (const Triangle< T > &tr)
- template<std::floating_point T>
  bool geom::detail::isOverlap (Segment2D< T > &segm1, Segment2D< T > &segm2)
- template<std::forward_iterator It>
  bool geom::detail::isAllPosNeg (It begin, It end)
- template<std::floating_point T>
  bool geom::detail::isAllPosNeg (T num1, T num2)
- template<std::floating_point T>
  bool geom::detail::isOnOneSide (const Plane< T > &pl, const Triangle< T > &tr)
- template<std::floating_point T>
  Trian2< T > geom::detail::getTrian2 (const Plane< T > &pl, const Triangle< T > &tr)
- template<std::floating_point T>
  bool geom::detail::isCounterClockwise (Trian2< T > &tr)
- template<std::floating_point T>
  Segment2D< T > geom::detail::computeInterval (const Trian2< T > &tr, const Vec2< T > &d)
- template<std::floating_point T>
  Segment3D< T > geom::detail::getSegment (const Triangle< T > &tr)
- template<std::bidirectional_iterator It>
  std::size_t geom::detail::roguePos (It begin, It end)

6.4 detail.hh

```
00001 #ifndef __INCLUDE_INTERSECTION_DETAIL_HH__
00002 #define __INCLUDE_INTERSECTION_DETAIL_HH__
00003
00004 #include <concepts>
00005 #include <variant>
00006
00007 #include "distance/distance.hh"
00008 #include "primitives/primitives.hh"
00009 #include "primitives/vec2.hh"
00010
00011 namespace geom::detail
00012 {
00013
00014 template <typename T>
00015 using Segment2D = std::pair<T, T>;
00016
00017 template <std::floating_point T>
00018 using Trian2 = std::array<Vec2<T>, 3>;
00019
00020 template <std::floating_point T>
00021 using Segment3D = std::pair<Vec3<T>, Vec3<T>>;
00022
00023 template <std::floating_point T>
00024 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2);
00025
00026 template <std::floating_point T>
00027 bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2);
00028
00029 template <std::floating_point T>
00030 Segment2D<T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &pl, const Line<T> &l);
00031
00032 template <std::floating_point T>
00033 bool isIntersectBothInvalid(const Triangle<T> &tr1, const Triangle<T> &tr2);
00034
00035 template <std::floating_point T>
00036 bool isIntersectValidInvalid(const Triangle<T> &valid, const Triangle<T> &invalid);
00037
00038 template <std::floating_point T>
00039 bool isIntersectPointTriangle(const Vec3<T> &pt, const Triangle<T> &tr);
00040
00041 template <std::floating_point T>
00042 bool isIntersectPointSegment(const Vec3<T> &pt, const Segment3D<T> &segm);
00043
00044 template <std::floating_point T>
00045 bool isIntersectSegmentSegment(const Segment3D<T> &segm1, const Segment3D<T> &segm2);
00046
00047 template <std::floating_point T>
00048 bool isPoint(const Triangle<T> &tr);
00049
00050 template <std::floating_point T>
```

```
00051 bool isOverlap(Segment2D<T> &segm1, Segment2D<T> &segm2);
00052
00053 template <std::forward_iterator It>
00054 bool isAllPosNeg(It begin, It end);
00055
00056 template <std::floating_point T>
00057 bool isAllPosNeg(T num1, T num2);
00058
00059 template <std::floating_point T>
00060 bool isOnOneSide(const Plane<T> &pl, const Triangle<T> &tr);
00061
00062 template <std::floating_point T>
00063 Trian2<T> getTrian2(const Plane<T> &pl, const Triangle<T> &tr);
00064
00065 template <std::floating_point T>
00066 bool isCounterClockwise(Trian2<T> &tr);
00067
00068 template <std::floating_point T>
00069 Segment2D<T> computeInterval(const Trian2<T> &tr, const Vec2<T> &d);
00070
00071 template <std::floating_point T>
00072 Segment3D<T> getSegment(const Triangle<T> &tr);
00073
00074 template <std::bidirectional_iterator It>
00075 std::size_t roguePos(It begin, It end);
00076
00077 //=========================================================================
00078
00079 template <std::floating_point T>
00080 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2)
00081 {
00082   auto pl = tr1.getPlane();
00083
00084   auto trian1 = getTrian2(pl, tr1);
00085   auto trian2 = getTrian2(pl, tr2);
00086
00087   for (auto trian : {trian1, trian2})
00088     for (std::size_t i0 = 0, i1 = 2; i0 < 3; i1 = i0, ++i0)
00089     {
00090       auto d = (trian[i0] - trian[i1]).getPerp();
00091
00092       auto s1 = computeInterval(trian1, d);
00093       auto s2 = computeInterval(trian2, d);
00094
00095       if (s2.second < s1.first || s1.second < s2.first)
00096         return false;
00097     }
00098
00099   return true;
00100 }
00101
00102 template <std::floating_point T>
00103 bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2)
00104 {
00105   auto pl1 = tr1.getPlane();
00106   auto pl2 = tr2.getPlane();
00107
00108   auto l = std::get<Line<T>>(intersect(pl1, pl2));
00109
00110   auto params1 = helperMollerHaines(tr1, pl2, l);
00111   auto params2 = helperMollerHaines(tr2, pl1, l);
00112
00113   return isOverlap(params1, params2);
00114 }
00115
00116 template <std::floating_point T>
00117 Segment2D<T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &pl, const Line<T> &l)
00118 {
00119   /* Project the triangle vertices onto line */
00120   std::array<T, 3> vert{};
00121   std::transform(tr.begin(), tr.end(), vert.begin(),
00122                  [dir = l.dir(), org = l.org()](auto &&v) { return dot(dir, v - org); });
00123
00124   std::array<T, 3> sdist{};
00125   std::transform(tr.begin(), tr.end(), sdist.begin(), std::bind_front(distance<T>, pl));
00126
00127   /* Looking for vertex which is alone on it's side */
00128   std::size_t rogue = roguePos(sdist.begin(), sdist.end());
00129
00130   std::array<T, 2> segm{};
00131   std::array<size_t, 2> arr{(rogue + 1) % 3, (rogue + 2) % 3};
00132   std::transform(arr.begin(), arr.end(), segm.begin(), [&vert, &sdist, rogue](auto i) {
00133     return vert[i] + (vert[rogue] - vert[i]) * sdist[i] / (sdist[i] - sdist[rogue]);
00134   });
00135
00136   return std::minmax(segm[0], segm[1]);
00137 }
```

```
00138
00139 template <std::floating_point T>
00140 bool isIntersectBothInvalid(const Triangle<T> &tr1, const Triangle<T> &tr2)
00141 {
00142   auto isPoint1 = isPoint(tr1);
00143   auto isPoint2 = isPoint(tr2);
00144
00145   if (isPoint1 && isPoint2)
00146     return tr1[0] == tr2[0];
00147
00148   if (isPoint1)
00149     return isIntersectPointSegment(tr1[0], getSegment(tr2));
00150
00151   if (isPoint2)
00152     return isIntersectPointSegment(tr2[0], getSegment(tr1));
00153
00154   return isIntersectSegmentSegment(getSegment(tr1), getSegment(tr2));
00155 }
00156
00157 template <std::floating_point T>
00158 bool isIntersectValidInvalid(const Triangle<T> &valid, const Triangle<T> &invalid)
00159 {
00160   if (isPoint(invalid))
00161     return isIntersectPointTriangle(invalid[0], valid);
00162
00163   auto segm = getSegment(invalid);
00164   auto pl = valid.getPlane();
00165
00166   auto dst1 = distance(pl, segm.first);
00167   auto dst2 = distance(pl, segm.second);
00168
00169   if (dst1 * dst2 > 0)
00170     return false;
00171
00172   if (isZeroThreshold(dst1) && isZeroThreshold(dst2))
00173     return isIntersect2D(valid, invalid);
00174
00175   dst1 = std::abs(dst1);
00176   dst2 = std::abs(dst2);
00177
00178   auto pt = segm.first + (segm.second - segm.first) * dst1 / (dst1 + dst2);
00179   return isIntersectPointTriangle(pt, valid);
00180 }
00181
00182 template <std::floating_point T>
00183 bool isIntersectPointTriangle(const Vec3<T> &pt, const Triangle<T> &tr)
00184 {
00185   if (!tr.getPlane().belongs(pt))
00186     return false;
00187
00188   /* TODO: comment better */
00189   /* pt = point + u * edge1 + v * edge2 */
00190   auto point = pt - tr[0];
00191   auto edge1 = tr[1] - tr[0];
00192   auto edge2 = tr[2] - tr[0];
00193
00194   auto dotE1E1 = dot(edge1, edge1);
00195   auto dotE1E2 = dot(edge1, edge2);
00196   auto dotE1PT = dot(edge1, point);
00197
00198   auto dotE2E2 = dot(edge2, edge2);
00199   auto dotE2PT = dot(edge2, point);
00200
00201   auto denom = dotE1E1 * dotE2E2 - dotE1E2 * dotE1E2;
00202   auto u = (dotE2E2 * dotE1PT - dotE1E2 * dotE2PT) / denom;
00203   auto v = (dotE1E1 * dotE2PT - dotE1E2 * dotE1PT) / denom;
00204
00205   /* Point belongs to triangle if: (u >= 0) && (v >= 0) && (u + v <= 1) */
00206   auto eps = ThresComp<T>::getThreshold();
00207   return (u > -eps) && (v > -eps) && (u + v < 1 + eps);
00208 }
00209
00210 template <std::floating_point T>
00211 bool isIntersectPointSegment(const Vec3<T> &pt, const Segment3D<T> &segm)
00212 {
00213   Line<T> l{segm.first, segm.second - segm.first};
00214   if (!l.belongs(pt))
00215     return false;
00216
00217   auto beg = dot(l.dir(), segm.first - pt);
00218   auto end = dot(l.dir(), segm.second - pt);
00219
00220   return !isAllPosNeg(beg, end);
00221 }
00222
00223 template <std::floating_point T>
00224 bool isIntersectSegmentSegment(const Segment3D<T> &segm1, const Segment3D<T> &segm2)
```

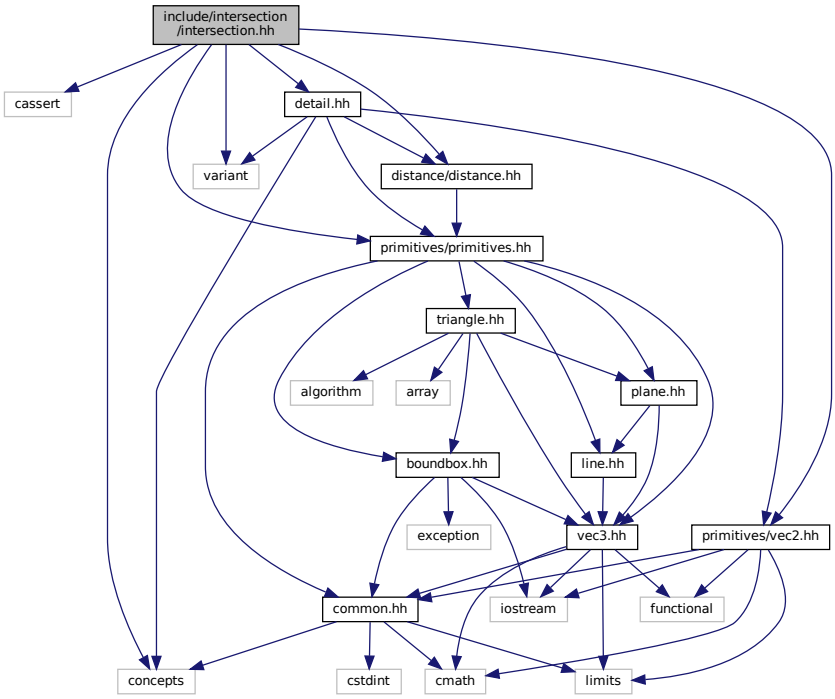
```
00225 {
00226   Line<T> l1{segm1.first, segm1.second - segm1.first};
00227   Line<T> l2{segm2.first, segm2.second - segm2.first};
00228   auto intersectionResult = intersect(l1, l2);
00229
00230   if (std::holds_alternative<Line<T>>(intersectionResult))
00231   {
00232     const auto &dir = l1.dir();
00233     Segment2D<T> s1{dot(dir, segm1.first), dot(dir, segm1.second)};
00234     Segment2D<T> s2{dot(dir, segm2.first), dot(dir, segm2.second)};
00235     return isOverlap(s1, s2);
00236   }
00237
00238   if (std::holds_alternative<Vec3<T>>(intersectionResult))
00239   {
00240     auto pt = std::get<Vec3<T»(intersectionResult);
00241     return isIntersectPointSegment(pt, segm1) && isIntersectPointSegment(pt, segm2);
00242   }
00243
00244   return false;
00245 }
00246
00247 template <std::floating_point T>
00248 bool isPoint(const Triangle<T> &tr)
00249 {
00250   return (tr[0] == tr[1]) && (tr[0] == tr[2]);
00251 }
00252
00253 template <std::floating_point T>
00254 bool isOverlap(Segment2D<T> &segm1, Segment2D<T> &segm2)
00255 {
00256   return (segm2.first <= segm1.second) && (segm2.second >= segm1.first);
00257 }
00258
00259 template <std::forward_iterator It>
00260 bool isAllPosNeg(It begin, It end)
00261 {
00262   if (begin == end)
00263     return true;
00264
00265   bool fst = (*begin > 0);
00266   return std::none_of(std::next(begin), end,
00267                       [fst](auto &&elt) { return (elt > 0) != fst || isZeroThreshold(elt); });
00268 }
00269
00270 template <std::floating_point T>
00271 bool isAllPosNeg(T num1, T num2)
00272 {
00273   auto thres = ThresComp<T>::getThreshold();
00274   return (num1 > thres && num2 > thres) || (num1 < -thres && num2 < -thres);
00275 }
00276
00277 template <std::floating_point T>
00278 bool isOnOneSide(const Plane<T> &pl, const Triangle<T> &tr)
00279 {
00280   std::array<T, 3> sdist{};
00281   std::transform(tr.begin(), tr.end(), sdist.begin(), std::bind_front(distance<T>, pl));
00282   return detail::isAllPosNeg(sdist.begin(), sdist.end());
00283 }
00284
00285 template <std::floating_point T>
00286 Trian2<T> getTrian2(const Plane<T> &pl, const Triangle<T> &tr)
00287 {
00288   auto norm = pl.norm();
00289
00290   const Vec3<T> x{1, 0, 0};
00291   const Vec3<T> y{0, 1, 0};
00292   const Vec3<T> z{0, 0, 1};
00293
00294   std::array<Vec3<T>, 3> xyz{x, y, z};
00295   std::array<T, 3> xyzDot;
00296
00297   std::transform(xyz.begin(), xyz.end(), xyzDot.begin(),
00298                  [&norm](const auto &axis) { return std::abs(dot(axis, norm)); });
00299
00300   auto maxIt = std::max_element(xyzDot.begin(), xyzDot.end());
00301   auto maxIdx = static_cast<std::size_t>(std::distance(xyzDot.begin(), maxIt));
00302
00303   Trian2<T> res;
00304   for (std::size_t i = 0; i < 3; ++i)
00305     for (std::size_t j = 0, k = 0; j < 2; ++j, ++k)
00306     {
00307       if (k == maxIdx)
00308         ++k;
00309
00310       res[i][j] = tr[i][k];
00311     }
```

```
00312
00313   if (!isCounterClockwise(res))
00314     std::swap(res[0], res[1]);
00315
00316   return res;
00317 }
00318
00319 template <std::floating_point T>
00320 bool isCounterClockwise(Trian2<T> &tr)
00321 {
00322   /**
00323    * The triangle is counterclockwise ordered if \delta > 0
00324    * and clockwise ordered if \delta < 0.
00325    *
00326    *              +  1  1  1 +
00327    * \delta = det | x0 x1 x2 | = (x1 * y2 - x2 * y1) - (x0 * y2 - x2 * y0)
00328    *              + y0 y1 y2 +                       + (x0 * y1 - x1 * y0)
00329    *
00330    */
00331
00332   auto x0 = tr[0][0], x1 = tr[1][0], x2 = tr[2][0];
00333   auto y0 = tr[0][1], y1 = tr[1][1], y2 = tr[2][1];
00334
00335   auto delta = (x1 * y2 - x2 * y1) - (x0 * y2 - x2 * y0) + (x0 * y1 - x1 * y0);
00336   return (delta > 0);
00337 }
00338
00339 template <std::floating_point T>
00340 Segment2D<T> computeInterval(const Trian2<T> &tr, const Vec2<T> &d)
00341 {
00342   std::array<T, 3> dotArr{};
00343   std::transform(tr.begin(), tr.end(), dotArr.begin(), [&d](auto &&v) { return dot(d, v); });
00344   auto mmIt = std::minmax_element(dotArr.begin(), dotArr.end());
00345   return {*mmIt.first, *mmIt.second};
00346 }
00347
00348 template <std::floating_point T>
00349 Segment3D<T> getSegment(const Triangle<T> &tr)
00350 {
00351   std::array<T, 3> lenArr{};
00352   for (std::size_t i = 0; i < 3; ++i)
00353     lenArr[i] = (tr[i] - tr[i + 1]).length2();
00354
00355   auto maxIt = std::max_element(lenArr.begin(), lenArr.end());
00356   auto maxIdx = static_cast<std::size_t>(std::distance(lenArr.begin(), maxIt));
00357
00358   return {tr[maxIdx], tr[maxIdx + 1]};
00359 }
00360
00361 template <std::bidirectional_iterator It>
00362 std::size_t roguePos(It beg, It end)
00363 {
00364   using T = typename std::iterator_traits<It>::value_type;
00365
00366   auto isDiffSides = [thres = ThresComp<T>::getThreshold()](auto lhs, auto rhs) {
00367     return (lhs > thres && rhs < -thres) || (lhs < -thres && rhs > thres);
00368   };
00369
00370   for (std::size_t i = 0; i < 3; ++i)
00371     if (isDiffSides(*(beg + i), *(beg + (i + 1) % 3)))
00372       return i;
00373
00374   std::array<bool, 3> isOneSide{};
00375   for (std::size_t i = 0; i < 3; ++i)
00376     isOneSide[i] = isAllPosNeg(*(beg + i), *(beg + (i + 1) % 3));
00377
00378   if (std::none_of(isOneSide.begin(), isOneSide.end(), std::identity{}))
00379   {
00380     auto rbeg = std::reverse_iterator(end);
00381     auto rend = std::reverse_iterator(beg);
00382     auto rogueIt = std::find_if_not(rbeg, rend, isZeroThreshold<T>);
00383     return (rogueIt == rend) ? 0 : std::distance(rogueIt, rend) - 1;
00384   }
00385
00386   for (std::size_t i = 0; i < 3; ++i)
00387     if (isOneSide[i])
00388       return (i + 2) % 3;
00389
00390   return 0;
00391 }
00392
00393 } // namespace geom::detail
00394
00395 #endif // __INCLUDE_INTERSECTION_DETAIL_HH__
```

6.5 include/intersection/intersection.hh File Reference

```
#include <cassert>
#include <concepts>
#include <variant>
#include "distance/distance.hh"
#include "primitives/primitives.hh"
#include "primitives/vec2.hh"
#include "detail.hh"
```

Include dependency graph for intersection.hh:



Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  bool geom::isIntersect (const Triangle< T > &tr1, const Triangle< T > &tr2)

  Checks intersection of 2 triangles.
- template<std::floating_point T>
  std::variant< std::monostate, Line< T >, Plane< T > > geom::intersect (const Plane< T > &pl1, const Plane< T > &pl2)

  Intersect 2 planes and return result of intersection.
- template<std::floating_point T>
  std::variant< std::monostate, Vec3< T >, Line< T > > geom::intersect (const Line< T > &l1, const Line< T > &l2)

  Intersect 2 lines and return result of intersection.

6.6 intersection.hh

```
00001 #ifndef __INCLUDE_INTERSECTION_INTERSECTION_HH__
00002 #define __INCLUDE_INTERSECTION_INTERSECTION_HH__
00003
00004 #include <cassert>
00005 #include <concepts>
00006 #include <variant>
00007
00008 #include "distance/distance.hh"
00009 #include "primitives/primitives.hh"
00010 #include "primitives/vec2.hh"
00011
00012 #include "detail.hh"
00013
00014 namespace geom
00015 {
00016
00017 /**
00018  * @brief Checks intersection of 2 triangles
00019  *
00020  * @tparam T - floating point type of coordinates
00021  * @param tr1 first triangle
00022  * @param tr2 second triangle
00023  * @return true if triangles are intersect
00024  * @return false if triangles are not intersect
00025  */
00026 template <std::floating_point T>
00027 bool isIntersect(const Triangle<T> &tr1, const Triangle<T> &tr2);
00028
00029 /**
00030  * @brief Intersect 2 planes and return result of intersection
00031  * @details
00032  * Common intersection case (parallel planes case is trivial):
00033  *
00034  * Let \f$ \overrightarrow{P} \f$ - point in space
00035  *
00036  * \f$ pl_1 \f$ equation: \f$ \overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1 \f$
00037  *
00038  * \f$ pl_2 \f$ equation: \f$ \overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2 \f$
00039  *
00040  * Intersection line direction: \f$ \overrightarrow{dir} = \overrightarrow{n}_1 \times
00041  * \overrightarrow{n}_2 \f$
00042  *
00043  * Let origin of intersection line be a linear combination of \f$ \overrightarrow{n}_1 \f$
00044  * and \f$ \overrightarrow{n}_2 \f$: \f[ \overrightarrow{P} = a \cdot \overrightarrow{n}_1
00045  * + b \cdot \overrightarrow{n}_2 \f]
00046  *
00047  * \f$ \overrightarrow{P} \f$ must satisfy both \f$ pl_1 \f$ and \f$ pl_1 \f$ equations:
00048  * \f[
00049  * \overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1
00050  * \Leftrightarrow
00051  * \overrightarrow{n}_1
00052  * \cdot
00053  * \left(
00054  *  a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2
00055  *  \right)
00056  *  = d_1
00057  * \Leftrightarrow
00058  * a + b \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2  = d_1
00059  * \f]
00060  * \f[
00061  * \overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2
00062  * \Leftrightarrow
00063  * \overrightarrow{n}_2
00064  * \cdot
00065  * \left(
00066  *  a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2
00067  *  \right) = d_2
00068  * \Leftrightarrow
00069  * a \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 + b = d_2
00070  * \f]
00071  *
00072  * Let's find \f$a\f$ and \f$b\f$:
00073  * \f[
00074  * a = \frac{
00075  *  d_2 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_1
00076  * }{
00077  *  \left( \overrightarrow{n}_1 \cdot \overrightarrow{n}_2\right)^2 - 1
00078  * }
00079  * \f]
00080  * \f[
00081  * b = \frac{
00082  * d_1 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_2
00083  * }{
00084  *  \left( \overrightarrow{n}_1 \cdot \overrightarrow{n}_2\right)^2 - 1
00085  * }
```

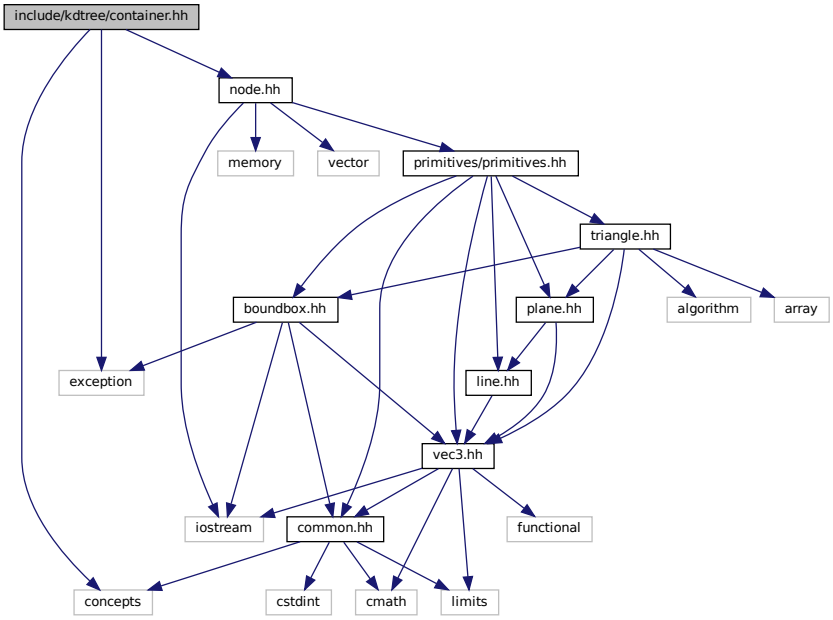
```
00086  * \f]
00087  *
00088  * Intersection line equation:
00089  * \f[
00090  * \overrightarrow{r}(t) = \overrightarrow{P} + t \cdot \overrightarrow{n}_1 \times
00091  * \overrightarrow{n}_2 = (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) +
00092  * t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2 \f]
00093  *
00094  * @tparam T - floating point type of coordinates
00095  * @param[in] pl1 first plane
00096  * @param[in] pl2 second plane
00097  * @return std::variant<std::monostate, Line<T>, Plane<T>»
00098  */
00099 template <std::floating_point T>
00100 std::variant<std::monostate, Line<T>, Plane<T>» intersect(const Plane<T> &pl1, const Plane<T> &pl2);
00101
00102 /**
00103  * @brief Intersect 2 lines and return result of intersection
00104  * @details
00105  * Common intersection case (parallel & skew lines cases are trivial):
00106  * Let \f$ \overrightarrow{P} \f$ - point in space, intersection point of two lines.
00107  *
00108  * \f$ l_1 \f$ equation: \f$ \overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 =
00109  * \overrightarrow{P} \f$
00110  *
00111  * \f$ l_2 \f$ equation: \f$ \overrightarrow{org}_2 + \overrightarrow{dir}_2
00112  * \cdot t_2 = \overrightarrow{P} \f$
00113  *
00114  * Let's equate left sides:
00115  * \f[
00116  * \overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 =
00117  * \overrightarrow{org}_2 + \overrightarrow{dir}_2 \cdot t_2
00118  * \f]
00119  * Cross multiply both sides from right by \f$ \overrightarrow{dir}_2 \f$:
00120  * \f[
00121  * t_1 \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right) =
00122  * \left(\overrightarrow{org}_2 - \overrightarrow{org}_1 \right) \times \overrightarrow{dir}_2
00123  * \f]
00124  * Dot multiply both sides by \f$ \frac{\overrightarrow{dir}_1 \times \overrightarrow{dir}_2}{\left|
00125  * \overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right|^2} \f$:
00126  *
00127  * \f[
00128  * t_1 = \frac{
00129  *  \left(\left(\overrightarrow{org}_2 - \overrightarrow{org}_1 \right) \times
00130  * \overrightarrow{dir}_2\right) \cdot \left( \overrightarrow{dir}_1 \times \overrightarrow{dir}_2
00131  * \right)
00132  * }{
00133  * \left| \overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right|^2
00134  * }
00135  * \f]
00136  *
00137  * Thus we get intersection point parameter \f$ t_1 \f$ on \f$ l_1 \f$, let's substitute it to \f$
00138  * l_1 \f$ equation: \f[ \overrightarrow{P} = \overrightarrow{org}_1 + \frac{
00139  *  \left(\left(\overrightarrow{org}_2 - \overrightarrow{org}_1 \right) \times
00140  * \overrightarrow{dir}_2\right) \cdot \left( \overrightarrow{dir}_1 \times \overrightarrow{dir}_2
00141  * \right)
00142  * }{
00143  * \left| \overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right|^2
00144  * } \cdot \overrightarrow{dir}_1
00145  * \f]
00146  *
00147  * @tparam T - floating point type of coordinates
00148  * @param[in] l1 first line
00149  * @param[in] l2 second line
00150  * @return std::variant<std::monostate, Vec3<T>, Line<T>»
00151  */
00152 template <std::floating_point T>
00153 std::variant<std::monostate, Vec3<T>, Line<T>» intersect(const Line<T> &l1, const Line<T> &l2);
00154
00155 template <std::floating_point T>
00156 bool isIntersect(const Triangle<T> &tr1, const Triangle<T> &tr2)
00157 {
00158   auto isInv1 = !tr1.isValid();
00159   auto isInv2 = !tr2.isValid();
00160
00161   if (isInv1 && isInv2)
00162     return detail::isIntersectBothInvalid(tr1, tr2);
00163
00164   if (isInv1)
00165     return detail::isIntersectValidInvalid(tr2, tr1);
00166
00167   if (isInv2)
00168     return detail::isIntersectValidInvalid(tr1, tr2);
00169
00170   auto pl1 = tr1.getPlane();
00171   if (detail::isOnOneSide(pl1, tr2))
00172     return false;
```

```
00173
00174   auto pl2 = tr2.getPlane();
00175   if (pl1 == pl2)
00176     return detail::isIntersect2D(tr1, tr2);
00177
00178   if (pl1.isPar(pl2))
00179     return false;
00180
00181   if (detail::isOnOneSide(pl2, tr1))
00182     return false;
00183
00184   return detail::isIntersectMollerHaines(tr1, tr2);
00185 }
00186
00187 template <std::floating_point T>
00188 std::variant<std::monostate, Line<T>, Plane<T>> intersect(const Plane<T> &pl1, const Plane<T> &pl2)
00189 {
00190   const auto &n1 = pl1.norm();
00191   const auto &n2 = pl2.norm();
00192
00193   auto dir = cross(n1, n2);
00194
00195   /* if planes are parallel */
00196   if (Vec3<T>{0} == dir)
00197   {
00198     if (pl1 == pl2)
00199       return pl1;
00200
00201     return std::monostate{};
00202   }
00203
00204   auto n1n2 = dot(n1, n2);
00205   auto d1 = pl1.dist();
00206   auto d2 = pl2.dist();
00207
00208   auto a = (d2 * n1n2 - d1) / (n1n2 * n1n2 - 1);
00209   auto b = (d1 * n1n2 - d2) / (n1n2 * n1n2 - 1);
00210
00211   return Line<T>{(a * n1) + (b * n2), dir};
00212 }
00213
00214 template <std::floating_point T>
00215 std::variant<std::monostate, Vec3<T>, Line<T>> intersect(const Line<T> &l1, const Line<T> &l2)
00216 {
00217   if (l1.isPar(l2))
00218   {
00219     if (l1.isEqual(l2))
00220       return l1;
00221
00222     return std::monostate{};
00223   }
00224
00225   if (l1.isSkew(l2))
00226     return std::monostate{};
00227
00228   auto dir1xdir2 = cross(l1.dir(), l2.dir());
00229   auto org21xdir2 = cross(l2.org() - l1.org(), l2.dir());
00230
00231   auto t1_intersect = dot(org21xdir2, dir1xdir2) / dir1xdir2.length2();
00232
00233   auto point = l1.getPoint(t1_intersect);
00234
00235   return point;
00236 }
00237
00238 } // namespace geom
00239
00240 #endif // __INCLUDE_INTERSECTION_INTERSECTION_HH__
```

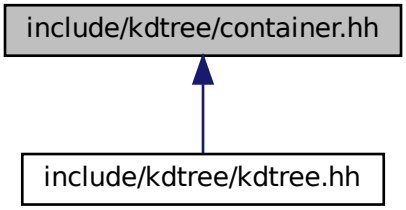
6.7 include/kdtree/container.hh File Reference

```
#include <concepts>
#include <exception>
#include "node.hh"
```

Include dependency graph for container.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::kdtree::KdTree< T >
- class geom::kdtree::Container< T >
- class geom::kdtree::Container< T >::ConstIterator

Namespaces

- geom

  line.hh Line class implementation
- geom::kdtree

6.8 container.hh

```
00001 #ifndef __INCLUDE_KDTREE_CONTAINER_HH__
00002 #define __INCLUDE_KDTREE_CONTAINER_HH__
00003
00004 #include <concepts>
00005 #include <exception>
00006
00007 #include "node.hh"
00008
00009 namespace geom::kdtree
00010 {
00011
00012 template <std::floating_point T>
00013 class KdTree;
00014
00015 template <std::floating_point T>
00016 class Container final
00017 {
00018 private:
00019   const KdTree<T> *tree_;
00020   const Node<T> *node_;
00021
00022 public:
00023   Container(const KdTree<T> *tree, const Node<T> *node);
00024
00025   class ConstIterator;
00026   ConstIterator cbegin() const &;
00027   ConstIterator cend() const &;
00028
00029   ConstIterator begin() const &;
00030   ConstIterator end() const &;
00031
00032   typename Node<T>::IndexConstIterator indexBegin() const &;
00033   typename Node<T>::IndexConstIterator indexEnd() const &;
00034
00035   T separator() const;
00036   Axis sepAxis() const;
00037   BoundBox<T> boundBox() const;
00038   const Triangle<T> &triangleByIndex(Index index) const &;
00039
00040   Container left() const;
00041   Container right() const;
00042
00043   bool isValid() const;
00044
00045   class ConstIterator final
00046   {
00047   public:
00048     using iterator_category = std::forward_iterator_tag;
00049     using difference_type = std::size_t;
00050     using value_type = Triangle<T>;
00051     using reference = const Triangle<T> &;
00052     using pointer = const Triangle<T> *;
00053
00054   private:
00055     const Container *cont_;
00056     std::vector<Index>::const_iterator curIdxIt_{};
00057
00058   public:
00059     ConstIterator(const Container *cont, bool isEnd = false);
00060
00061     Index getIndex();
00062
00063     ConstIterator &operator++();
00064     ConstIterator operator++(int);
00065
00066     reference operator*() const;
00067     pointer operator->() const;
00068
00069     bool operator==(const ConstIterator &lhs) const = default;
00070   };
00071 };
00072
00073 //=================================================================================================
00074 //                                    Container definitions
00075 //=================================================================================================
00076
00077 template <std::floating_point T>
00078 Container<T>::Container(const KdTree<T> *tree, const Node<T> *node) : tree_(tree), node_(node)
00079 {}
00080
00081 template <std::floating_point T>
00082 typename Container<T>::ConstIterator Container<T>::cbegin() const &
00083 {
00084   return ConstIterator{this};
00085 }
```

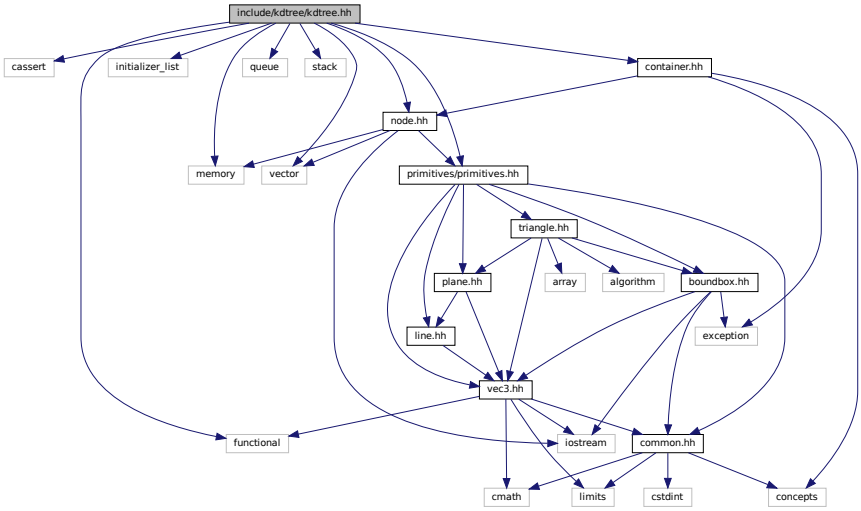
```
00086
00087 template <std::floating_point T>
00088 typename Container<T>::ConstIterator Container<T>::cend() const &
00089 {
00090   return ConstIterator{this, /* isEnd = */ true};
00091 }
00092
00093 template <std::floating_point T>
00094 typename Container<T>::ConstIterator Container<T>::begin() const &
00095 {
00096   return cbegin();
00097 }
00098
00099 template <std::floating_point T>
00100 typename Container<T>::ConstIterator Container<T>::end() const &
00101 {
00102   return cend();
00103 }
00104
00105 template <std::floating_point T>
00106 typename Node<T>::IndexConstIterator Container<T>::indexBegin() const &
00107 {
00108   return node_->indicies.begin();
00109 }
00110
00111 template <std::floating_point T>
00112 typename Node<T>::IndexConstIterator Container<T>::indexEnd() const &
00113 {
00114   return node_->indicies.end();
00115 }
00116
00117 template <std::floating_point T>
00118 T Container<T>::separator() const
00119 {
00120   return node_->separator;
00121 }
00122
00123 template <std::floating_point T>
00124 Axis Container<T>::sepAxis() const
00125 {
00126   return node_->sepAxis;
00127 }
00128
00129 template <std::floating_point T>
00130 BoundBox<T> Container<T>::boundBox() const
00131 {
00132   return node_->boundBox;
00133 }
00134
00135 template <std::floating_point T>
00136 const Triangle<T> &Container<T>::triangleByIndex(Index index) const &
00137 {
00138   return tree_->triangleByIndex(index);
00139 }
00140
00141 template <std::floating_point T>
00142 Container<T> Container<T>::left() const
00143 {
00144   return Container<T>{tree_, node_->left.get()};
00145 }
00146
00147 template <std::floating_point T>
00148 Container<T> Container<T>::right() const
00149 {
00150   return Container<T>{tree_, node_->right.get()};
00151 }
00152
00153 template <std::floating_point T>
00154 bool Container<T>::isValid() const
00155 {
00156   return (tree_ != nullptr) && (node_ != nullptr);
00157 }
00158
00159 //=================================================================================================
00160 //                                Container::ConstIterator definitions
00161 //=================================================================================================
00162
00163 template <std::floating_point T>
00164 Container<T>::ConstIterator::ConstIterator(const Container<T> *cont, bool isEnd) : cont_(cont)
00165 {
00166   if (nullptr == cont_)
00167     throw std::invalid_argument("Tried to create iterator with invalid Container pointer");
00168
00169   if (isEnd)
00170     curIdxIt_ = cont_->indexEnd();
00171   else
00172     curIdxIt_ = cont_->indexBegin();
```

```
00173 }
00174
00175 template <std::floating_point T>
00176 Index Container<T>::ConstIterator::getIndex()
00177 {
00178   return *curIdxIt_;
00179 }
00180
00181 template <std::floating_point T>
00182 typename Container<T>::ConstIterator &Container<T>::ConstIterator::operator++()
00183 {
00184   ++curIdxIt_;
00185   return *this;
00186 }
00187
00188 template <std::floating_point T>
00189 typename Container<T>::ConstIterator Container<T>::ConstIterator::operator++(int)
00190 {
00191   auto tmp = *this;
00192   operator++();
00193   return tmp;
00194 }
00195
00196 template <std::floating_point T>
00197 typename Container<T>::ConstIterator::reference Container<T>::ConstIterator::operator*() const
00198 {
00199   return cont_->triangleByIndex(*curIdxIt_);
00200 }
00201
00202 template <std::floating_point T>
00203 typename Container<T>::ConstIterator::pointer Container<T>::ConstIterator::operator->() const
00204 {
00205   return &cont_->triangleByIndex(*curIdxIt_);
00206 }
00207
00208 } // namespace geom::kdtree
00209
00210 #endif // __INCLUDE_KDTREE_CONTAINER_HH__
```

6.9 include/kdtree/kdtree.hh File Reference

```
#include <cassert>
#include <functional>
#include <initializer_list>
#include <memory>
#include <queue>
#include <stack>
#include <vector>
#include "primitives/primitives.hh"
#include "container.hh"
#include "node.hh"
```

Include dependency graph for kdtree.hh:



Classes

- class geom::kdtree::KdTree< T >
- struct geom::kdtree::KdTree< T >::ContainerPtr
- class geom::kdtree::KdTree< T >::ConstIterator

Namespaces

- geom

  line.hh Line class implementation
- geom::kdtree

6.10 kdtree.hh

```
00001 #ifndef __INCLUDE_KDTREE_KDTREE_HH__
00002 #define __INCLUDE_KDTREE_KDTREE_HH__
00003
00004 #include <cassert>
00005 #include <functional>
00006 #include <initializer_list>
00007 #include <memory>
00008 #include <queue>
00009 #include <stack>
00010 #include <vector>
00011
00012 #include "primitives/primitives.hh"
00013
00014 #include "container.hh"
00015 #include "node.hh"
00016
00017 namespace geom::kdtree
00018 {
00019
00020 template <std::floating_point T>
00021 class KdTree final
00022 {
00023 private:
00024   std::unique_ptr<Node<T>> root_{};
00025   std::vector<Triangle<T>> triangles_{};
00026   std::size_t nodeCapacity_{1};
```

```
00027
00028 public:
00029   KdTree(std::initializer_list<Triangle<T>> il);
00030   KdTree(const KdTree &tree);
00031   KdTree(KdTree &&tree) = default;
00032   KdTree() = default;
00033   ~KdTree();
00034
00035   KdTree &operator=(const KdTree &tree);
00036   KdTree &operator=(KdTree &&tree) = default;
00037
00038   class ConstIterator;
00039
00040   // ConstIterators
00041   ConstIterator cbegin() const &;
00042   ConstIterator cend() const &;
00043
00044   ConstIterator begin() const &;
00045   ConstIterator end() const &;
00046
00047   ConstIterator beginFrom(const ConstIterator &iter) const &;
00048
00049   // Modifiers
00050   void insert(const Triangle<T> &tr);
00051   void clear();
00052   void setNodeCapacity(std::size_t newCap);
00053
00054   // Capacity
00055   bool empty() const;
00056   std::size_t size() const;
00057   std::size_t nodeCapacity() const;
00058
00059   const Triangle<T> &triangleByIndex(Index index) const &;
00060
00061   void dumpRecursive(std::ostream &ost = std::cout) const;
00062
00063   static bool isOnPosSide(Axis axis, T separator, const Triangle<T> &tr);
00064   static bool isOnNegSide(Axis axis, T separator, const Triangle<T> &tr);
00065   static bool isOnSide(Axis axis, T separator, const Triangle<T> &tr,
00066                        std::function<bool(T, T)> comparator);
00067
00068 private:
00069   void expandingInsert(const Triangle<T> &tr);
00070   void tryExpandRight(Axis axis, const BoundBox<T> &trianBB);
00071   void tryExpandLeft(Axis axis, const BoundBox<T> &trianBB);
00072
00073   void nonExpandingInsert(Node<T> *node, const Triangle<T> &tr, Index index, bool isSubdiv = false);
00074   bool isDivisable(const Node<T> *node);
00075   void subdivide(Node<T> *node);
00076
00077 public:
00078   struct ContainerPtr final
00079   {
00080     Container<T> cont;
00081     const Container<T> *operator->() const;
00082   };
00083
00084   class ConstIterator final
00085   {
00086   public:
00087     using iterator_category = std::forward_iterator_tag;
00088     using difference_type = std::size_t;
00089     using value_type = Container<T>;
00090     using reference = Container<T>;
00091     using pointer = ContainerPtr;
00092
00093   private:
00094     const KdTree<T> *tree_;
00095     const Node<T> *node_;
00096     std::queue<const Node<T> *> fifo_;
00097
00098   public:
00099     ConstIterator(const KdTree<T> *tree, const Node<T> *node);
00100
00101     ConstIterator &operator++();
00102     ConstIterator operator++(int);
00103
00104     reference operator*() const;
00105     pointer operator->() const;
00106
00107     bool operator==(const ConstIterator &lhs) const;
00108     bool operator!=(const ConstIterator &lhs) const;
00109
00110     static ConstIterator beginFrom(const ConstIterator &iter);
00111   };
00112 };
00113
```

```
00114 //=================================================================================================
00115 //                                    KdTree definitions
00116 //=================================================================================================
00117
00118 template <std::floating_point T>
00119 KdTree<T>::KdTree(std::initializer_list<Triangle<T>> il)
00120 {
00121   for (const auto &tr : il)
00122     insert(tr);
00123 }
00124
00125 template <std::floating_point T>
00126 KdTree<T>::KdTree(const KdTree<T> &tree)
00127 {
00128   // temporary solution
00129   for (const auto &tr : tree.triangles_)
00130     insert(tr);
00131 }
00132
00133 template <std::floating_point T>
00134 KdTree<T>::~KdTree()
00135 {
00136   clear();
00137 }
00138
00139 template <std::floating_point T>
00140 KdTree<T> &KdTree<T>::operator=(const KdTree<T> &tree)
00141 {
00142   KdTree tmp{tree};
00143   operator=(std::move(tmp));
00144   return *this;
00145 }
00146
00147 // ConstIterators
00148 template <std::floating_point T>
00149 typename KdTree<T>::ConstIterator KdTree<T>::cbegin() const &
00150 {
00151   return ConstIterator{this, root_.get()};
00152 }
00153
00154 template <std::floating_point T>
00155 typename KdTree<T>::ConstIterator KdTree<T>::cend() const &
00156 {
00157   return ConstIterator{this, nullptr};
00158 }
00159
00160 template <std::floating_point T>
00161 typename KdTree<T>::ConstIterator KdTree<T>::begin() const &
00162 {
00163   return cbegin();
00164 }
00165
00166 template <std::floating_point T>
00167 typename KdTree<T>::ConstIterator KdTree<T>::end() const &
00168 {
00169   return cend();
00170 }
00171
00172 template <std::floating_point T>
00173 typename KdTree<T>::ConstIterator KdTree<T>::beginFrom(
00174   const typename KdTree<T>::ConstIterator &iter) const &
00175 {
00176   return KdTree<T>::ConstIterator::beginFrom(iter);
00177 }
00178
00179 // Modifiers
00180 template <std::floating_point T>
00181 void KdTree<T>::insert(const Triangle<T> &tr)
00182 {
00183   if (nullptr == root_)
00184   {
00185     root_ = std::unique_ptr<Node<T»{new Node<T>{T{}, Axis::NONE, tr.boundBox(), {0}}};
00186     triangles_.push_back(tr);
00187     return;
00188   }
00189
00190   if (!tr.belongsTo(root_->boundBox))
00191     expandingInsert(tr);
00192   else
00193   {
00194     auto index = triangles_.size();
00195     triangles_.push_back(tr);
00196     nonExpandingInsert(root_.get(), tr, index);
00197   }
00198 }
00199
00200 template <std::floating_point T>
```

```
00201 void KdTree<T>::clear()
00202 {
00203   if (nullptr == root_)
00204     return;
00205
00206   std::stack<std::unique_ptr<Node<T» *> stack{};
00207   stack.push(&root_);
00208
00209   while (!stack.empty())
00210   {
00211     auto *curNode = stack.top();
00212     auto *right = &curNode->get()->right;
00213     auto *left = &curNode->get()->left;
00214
00215     if ((nullptr == *right) && (nullptr == *left))
00216     {
00217       curNode->reset();
00218       stack.pop();
00219       continue;
00220     }
00221
00222     stack.push(right);
00223     stack.push(left);
00224   }
00225 }
00226
00227 template <std::floating_point T>
00228 void KdTree<T>::setNodeCapacity(std::size_t newCap)
00229 {
00230   nodeCapacity_ = newCap;
00231 }
00232
00233 // Capacity
00234 template <std::floating_point T>
00235 bool KdTree<T>::empty() const
00236 {
00237   return triangles_.empty();
00238 }
00239
00240 template <std::floating_point T>
00241 std::size_t KdTree<T>::size() const
00242 {
00243   return triangles_.size();
00244 }
00245
00246 template <std::floating_point T>
00247 std::size_t KdTree<T>::nodeCapacity() const
00248 {
00249   return nodeCapacity_;
00250 }
00251
00252 template <std::floating_point T>
00253 const Triangle<T> &KdTree<T>::triangleByIndex(Index index) const &
00254 {
00255   return triangles_[index];
00256 }
00257
00258 template <std::floating_point T>
00259 void KdTree<T>::dumpRecursive(std::ostream &ost) const
00260 {
00261   ost « "digraph kdtree {" « std::endl;
00262   if (root_)
00263     root_->dumpRecursive(ost);
00264   ost « "}" « std::endl;
00265 }
00266
00267 template <std::floating_point T>
00268 bool KdTree<T>::isOnPosSide(Axis axis, T separator, const Triangle<T> &tr)
00269 {
00270   return isOnSide(axis, separator, tr, std::greater<T>{});
00271 }
00272
00273 template <std::floating_point T>
00274 bool KdTree<T>::isOnNegSide(Axis axis, T separator, const Triangle<T> &tr)
00275 {
00276   return isOnSide(axis, separator, tr, std::less<T>{});
00277 }
00278
00279 template <std::floating_point T>
00280 bool KdTree<T>::isOnSide(Axis axis, T separator, const Triangle<T> &tr,
00281                          std::function<bool(T, T)> comparator)
00282 {
00283   if (Axis::NONE == axis)
00284     return false;
00285
00286   auto axisIdx = static_cast<size_t>(axis);
00287   return std::all_of(tr.begin(), tr.end(),
```

```
00288                     [&](auto &&v) { return comparator(v[axisIdx], separator); });
00289 }
00290
00291 template <std::floating_point T>
00292 void KdTree<T>::expandingInsert(const Triangle<T> &tr)
00293 {
00294   auto trianBB = tr.boundBox();
00295   auto index = triangles_.size();
00296   triangles_.push_back(tr);
00297
00298   for (auto axis : {Axis::X, Axis::Y, Axis::Z})
00299     tryExpandRight(axis, trianBB);
00300
00301   for (auto axis : {Axis::X, Axis::Y, Axis::Z})
00302     tryExpandLeft(axis, trianBB);
00303
00304   root_->indicies.push_back(index);
00305 }
00306
00307 template <std::floating_point T>
00308 void KdTree<T>::tryExpandRight(Axis axis, const BoundBox<T> &trianBB)
00309 {
00310   const auto &rootBB = root_->boundBox;
00311   if (trianBB.max(axis) <= rootBB.max(axis))
00312     return;
00313
00314   auto newRightBB = rootBB;
00315   newRightBB.min(axis) = rootBB.max(axis);
00316   newRightBB.max(axis) = trianBB.max(axis);
00317
00318   auto newRootBB = rootBB;
00319   newRootBB.max(axis) = newRightBB.max(axis);
00320
00321   std::unique_ptr<Node<T>> newRight{new Node<T>{T{}, Axis::NONE, newRightBB}};
00322   std::unique_ptr<Node<T>> newRoot{new Node<T>{rootBB.max(axis), axis, newRootBB}};
00323
00324   newRoot->right = std::move(newRight);
00325   newRoot->left = std::move(root_);
00326
00327   root_ = std::move(newRoot);
00328 }
00329
00330 template <std::floating_point T>
00331 void KdTree<T>::tryExpandLeft(Axis axis, const BoundBox<T> &trianBB)
00332 {
00333   const auto &rootBB = root_->boundBox;
00334   if (trianBB.min(axis) >= rootBB.min(axis))
00335     return;
00336
00337   BoundBox<T> newLeftBB = rootBB;
00338   newLeftBB.max(axis) = rootBB.min(axis);
00339   newLeftBB.min(axis) = trianBB.min(axis);
00340
00341   BoundBox<T> newRootBB = rootBB;
00342   newRootBB.min(axis) = newLeftBB.min(axis);
00343
00344   std::unique_ptr<Node<T>> newLeft{new Node<T>{T{}, Axis::NONE, newLeftBB}};
00345   std::unique_ptr<Node<T>> newRoot{new Node<T>{rootBB.min(axis), axis, newRootBB}};
00346
00347   newRoot->left = std::move(newLeft);
00348   newRoot->right = std::move(root_);
00349
00350   root_ = std::move(newRoot);
00351 }
00352
00353 template <std::floating_point T>
00354 void KdTree<T>::nonExpandingInsert(Node<T> *node, const Triangle<T> &tr, Index index, bool isSubdiv)
00355 {
00356   auto curNode = node;
00357   while (true)
00358   {
00359     if (isOnPosSide(curNode->sepAxis, curNode->separator, tr))
00360       curNode = curNode->right.get();
00361     else if (isOnNegSide(curNode->sepAxis, curNode->separator, tr))
00362       curNode = curNode->left.get();
00363     else
00364       break;
00365   }
00366
00367   curNode->indicies.push_back(index);
00368   if (isDivisable(curNode) && (!isSubdiv))
00369     subdivide(curNode);
00370 }
00371
00372 template <std::floating_point T>
00373 bool KdTree<T>::isDivisable(const Node<T> *node)
00374 {
```

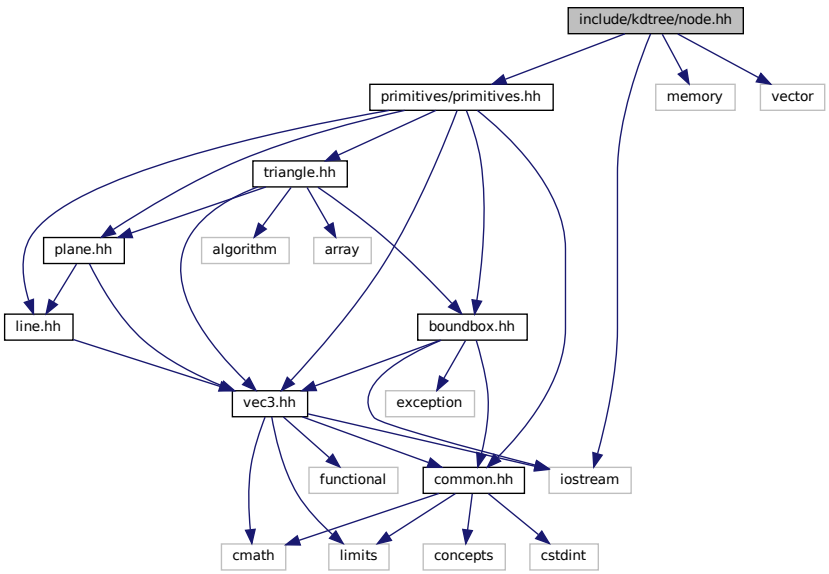
```
00375   return (node->indicies.size() > nodeCapacity_) && (node->sepAxis == Axis::NONE);
00376 }
00377
00378 template <std::floating_point T>
00379 void KdTree<T>::subdivide(Node<T> *node)
00380 {
00381   const auto &nodeBB = node->boundBox;
00382   auto axis = node->sepAxis = nodeBB.getMaxDim();
00383   auto sep = node->separator = nodeBB.min(axis) + (nodeBB.max(axis) - nodeBB.min(axis)) / 2;
00384
00385   auto newRightBB = nodeBB;
00386   auto newLeftBB = nodeBB;
00387
00388   newRightBB.min(axis) = newLeftBB.max(axis) = sep;
00389   node->right.reset(new Node<T>{T{}, Axis::NONE, newRightBB});
00390   node->left.reset(new Node<T>{T{}, Axis::NONE, newLeftBB});
00391
00392   auto indicies = node->indicies;
00393   node->indicies.clear();
00394
00395   for (auto index : indicies)
00396     nonExpandingInsert(node, triangles_[index], index, /* isSubdiv = */ true);
00397 }
00398
00399 //================================================================================================
00400 //                              KdTree::ContainerPtr definitions
00401 //================================================================================================
00402
00403 template <std::floating_point T>
00404 const Container<T> *KdTree<T>::ContainerPtr::operator->() const
00405 {
00406   return &cont;
00407 }
00408
00409 //================================================================================================
00410 //                              KdTree::ConstIterator definitions
00411 //================================================================================================
00412
00413 template <std::floating_point T>
00414 KdTree<T>::ConstIterator::ConstIterator(const KdTree<T> *tree, const Node<T> *node)
00415   : tree_(tree), node_(node), fifo_({node})
00416 {}
00417
00418 template <std::floating_point T>
00419 typename KdTree<T>::ConstIterator &KdTree<T>::ConstIterator::operator++()
00420 {
00421   if (0 == fifo_.size())
00422     return *this;
00423
00424   auto fifoEntry = fifo_.front();
00425   fifo_.pop();
00426
00427   if (Axis::NONE != fifoEntry->sepAxis)
00428   {
00429     if (nullptr != fifoEntry->left)
00430       fifo_.push(fifoEntry->left.get());
00431     if (nullptr != fifoEntry->right)
00432       fifo_.push(fifoEntry->right.get());
00433   }
00434
00435   node_ = (0 == fifo_.size()) ? nullptr : fifo_.front();
00436   return *this;
00437 }
00438
00439 template <std::floating_point T>
00440 typename KdTree<T>::ConstIterator KdTree<T>::ConstIterator::operator++(int)
00441 {
00442   auto tmp = *this;
00443   operator++();
00444   return tmp;
00445 }
00446
00447 template <std::floating_point T>
00448 typename KdTree<T>::ConstIterator::reference KdTree<T>::ConstIterator::operator*() const
00449 {
00450   return Container<T>{tree_, node_};
00451 }
00452
00453 template <std::floating_point T>
00454 typename KdTree<T>::ConstIterator::pointer KdTree<T>::ConstIterator::operator->() const
00455 {
00456   return ContainerPtr{{tree_, node_}};
00457 }
00458
00459 template <std::floating_point T>
00460 bool KdTree<T>::ConstIterator::operator==(const KdTree<T>::ConstIterator &lhs) const
00461 {
```

```
00462   return (tree_ == lhs.tree_) && (node_ == lhs.node_);
00463 }
00464
00465 template <std::floating_point T>
00466 bool KdTree<T>::ConstIterator::operator!=(const KdTree<T>::ConstIterator &lhs) const
00467 {
00468   return !operator==(lhs);
00469 }
00470
00471 template <std::floating_point T>
00472 typename KdTree<T>::ConstIterator KdTree<T>::ConstIterator::beginFrom(
00473   const typename KdTree<T>::ConstIterator &iter)
00474 {
00475   return ConstIterator{iter.tree_, iter.node_};
00476 }
00477
00478 } // namespace geom::kdtree
00479
00480 #endif // __INCLUDE_KDTREE_KDTREE_HH__
```

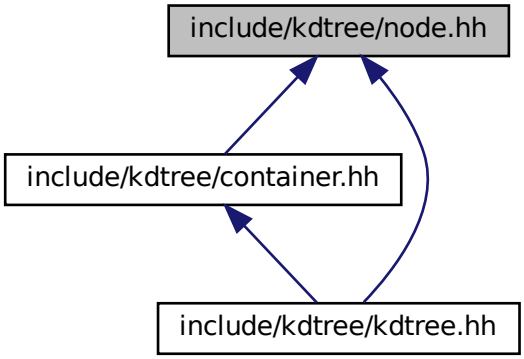
6.11 include/kdtree/node.hh File Reference

```
#include <iostream>
#include <memory>
#include <vector>
#include "primitives/primitives.hh"
```

Include dependency graph for node.hh:



This graph shows which files directly or indirectly include this file:



Classes

- struct geom::kdtree::Node< T >

Namespaces

- geom

  line.hh Line class implementation
- geom::kdtree

Typedefs

- using geom::kdtree::Index = std::size_t

6.12 node.hh

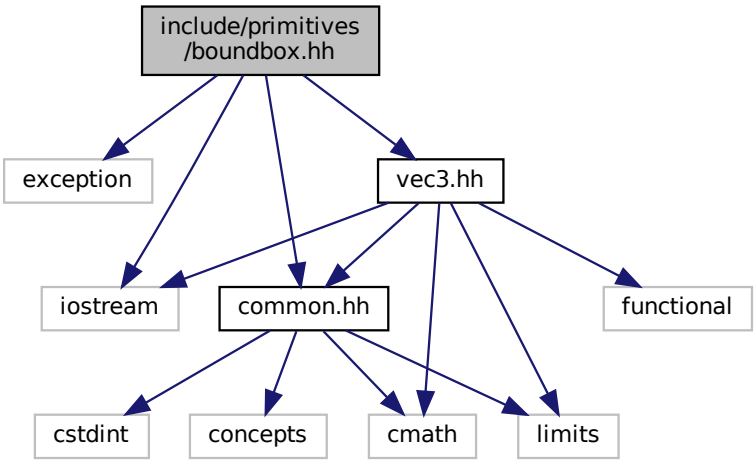
```
00001 #ifndef __INCLUDE_KDTREE_NODE_HH__
00002 #define __INCLUDE_KDTREE_NODE_HH__
00003
00004 #include <iostream>
00005 #include <memory>
00006 #include <vector>
00007
00008 #include "primitives/primitives.hh"
00009
00010 namespace geom::kdtree
00011 {
00012
00013 using Index = std::size_t;
00014
00015 template <std::floating_point T>
00016 struct Node final
00017 {
00018   T separator{};            // separator's coordinate on separation axis
00019   Axis sepAxis{Axis::NONE}; // separation axis
00020   BoundBox<T> boundBox{};
00021   std::vector<Index> indicies{};
00022
```

```
00023   std::unique_ptr<Node> left{nullptr};
00024   std::unique_ptr<Node> right{nullptr};
00025
00026   using IndexIterator = std::vector<Index>::iterator;
00027   using IndexConstIterator = std::vector<Index>::const_iterator;
00028
00029   void dumpRecursive(std::ostream &ost) const;
00030 };
00031
00032 template <std::floating_point T>
00033 void Node<T>::dumpRecursive(std::ostream &ost) const
00034 {
00035   ost « reinterpret_cast<std::uintptr_t>(this)
00036       « " [shape=box,label=\"axis: " « static_cast<int>(sepAxis) « ",\\n"
00037       « boundBox « ",\\nvec: {";
00038
00039   for (auto elem : indicies)
00040     ost « elem « " ";
00041
00042   ost « "}\"];" « std::endl;
00043
00044   if (left)
00045   {
00046     left->dumpRecursive(ost);
00047     ost « reinterpret_cast<std::uintptr_t>(this) « " -> "
00048         « reinterpret_cast<std::uintptr_t>(left.get()) « " [label=\"L\"];" « std::endl;
00049   }
00050   if (right)
00051   {
00052     right->dumpRecursive(ost);
00053     ost « reinterpret_cast<std::uintptr_t>(this) « " -> "
00054         « reinterpret_cast<std::uintptr_t>(right.get()) « " [label=\"R\"];" « std::endl;
00055   }
00056 }
00057
00058 } // namespace geom::kdtree
00059
00060 #endif // __INCLUDE_KDTREE_NODE_HH__
```

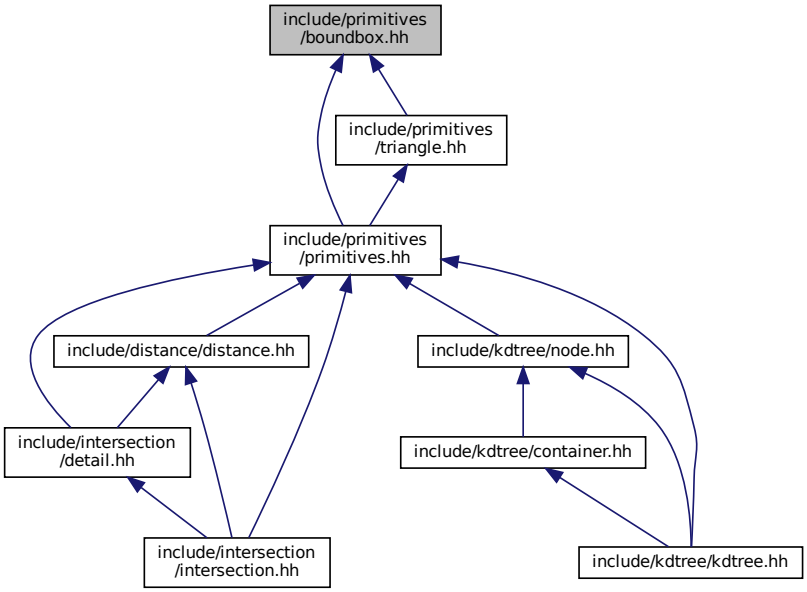
6.13 include/primitives/boundbox.hh File Reference

```
#include <exception>
#include <iostream>
#include "common.hh"
#include "vec3.hh"
```

Include dependency graph for boundbox.hh:



This graph shows which files directly or indirectly include this file:



Classes

- struct geom::BoundBox< T >

Namespaces

- geom

  line.hh Line class implementation

Macros

- #define BBFILL(minmax)

Functions

- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const BoundBox< T > &bb)

6.13.1 Macro Definition Documentation

6.13.1.1 BBFILL

```
#define BBFILL(
               minmax )
```

Value:

```
  do                                                                                                  \
  {                                                                                                   \
    switch (axis)                                                                                     \
    {                                                                                                 \
    case Axis::X:                                                                                     \
      return minmax##X;                                                                               \
    case Axis::Y:                                                                                     \
      return minmax##Y;                                                                               \
    case Axis::Z:                                                                                     \
      return minmax##Z;                                                                               \
    case Axis::NONE:                                                                                  \
    default:                                                                                          \
      throw std::logic_error("BoundBox<T>::" #minmax " (): Wrong input axis");                        \
    }                                                                                                 \
  } while (false)
```

Definition at line 49 of file boundbox.hh.

6.14 boundbox.hh

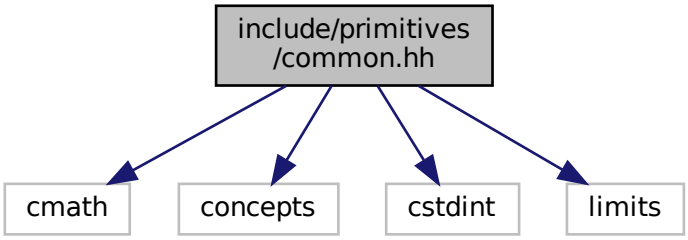
```
00001 #ifndef __INCLUDE_PRIMITIVES_BOUNDBOX_HH__
00002 #define __INCLUDE_PRIMITIVES_BOUNDBOX_HH__
00003
00004 #include <exception>
00005 #include <iostream>
00006
00007 #include "common.hh"
00008 #include "vec3.hh"
00009
00010 namespace geom
00011 {
00012
00013 template <std::floating_point T>
00014 struct BoundBox final
00015 {
00016   T minX{};
00017   T maxX{};
00018
00019   T minY{};
00020   T maxY{};
00021
00022   T minZ{};
00023   T maxZ{};
00024
00025   bool belongsTo(const BoundBox<T> &bb);
00026
00027   T &min(Axis axis) &;
00028   T &max(Axis axis) &;
00029
00030   T min(Axis axis) &&;
00031   T max(Axis axis) &&;
00032
00033   T min(Axis axis) const &;
00034   T max(Axis axis) const &;
00035
00036   Axis getMaxDim() const;
00037
00038   bool operator==(const BoundBox &rhs) const;
00039   bool operator!=(const BoundBox &rhs) const;
00040 };
00041
00042 template <std::floating_point T>
00043 bool BoundBox<T>::belongsTo(const BoundBox<T> &bb)
00044 {
00045   return (minX >= bb.minX) && (minY >= bb.minY) && (minZ >= bb.minZ) && (maxX <= bb.maxX) &&
00046          (maxY <= bb.maxY) && (maxZ <= bb.maxZ);
00047 }
00048
00049 #define BBFILL(minmax)                                                                        \
00050   do                                                                                          \
00051   {                                                                                           \
00052     switch (axis)                                                                             \
00053     {                                                                                         \
```

```
00054     case Axis::X:                                                                \
00055       return minmax##X;                                                          \
00056     case Axis::Y:                                                                \
00057       return minmax##Y;                                                          \
00058     case Axis::Z:                                                                \
00059       return minmax##Z;                                                          \
00060     case Axis::NONE:                                                             \
00061     default:                                                                     \
00062       throw std::logic_error("BoundBox<T>::" #minmax " (): Wrong input axis");   \
00063     }                                                                            \
00064   } while (false)
00065
00066 template <std::floating_point T>
00067 T &BoundBox<T>::min(Axis axis) &
00068 {
00069   BBFILL(min);
00070 }
00071
00072 template <std::floating_point T>
00073 T &BoundBox<T>::max(Axis axis) &
00074 {
00075   BBFILL(max);
00076 }
00077
00078 template <std::floating_point T>
00079 T BoundBox<T>::min(Axis axis) &&
00080 {
00081   BBFILL(min);
00082 }
00083
00084 template <std::floating_point T>
00085 T BoundBox<T>::max(Axis axis) &&
00086 {
00087   BBFILL(max);
00088 }
00089
00090 template <std::floating_point T>
00091 T BoundBox<T>::min(Axis axis) const &
00092 {
00093   BBFILL(min);
00094 }
00095
00096 template <std::floating_point T>
00097 T BoundBox<T>::max(Axis axis) const &
00098 {
00099   BBFILL(max);
00100 }
00101
00102 #undef BBFILL
00103
00104 template <std::floating_point T>
00105 Axis BoundBox<T>::getMaxDim() const
00106 {
00107   return std::max({Axis::X, Axis::Y, Axis::Z}, [this](auto lhs, auto rhs) {
00108     return (this->max(lhs) - this->min(lhs)) < (this->max(rhs) - this->min(rhs));
00109   });
00110 }
00111
00112 template <std::floating_point T>
00113 bool BoundBox<T>::operator==(const BoundBox &rhs) const
00114 {
00115   return isEqualThreshold(minX, rhs.minX) && isEqualThreshold(maxX, rhs.maxX) &&
00116          isEqualThreshold(minY, rhs.minY) && isEqualThreshold(maxY, rhs.maxY) &&
00117          isEqualThreshold(minZ, rhs.minZ) && isEqualThreshold(maxY, rhs.maxY);
00118 }
00119
00120 template <std::floating_point T>
00121 bool BoundBox<T>::operator!=(const BoundBox &rhs) const
00122 {
00123   return !operator==(rhs);
00124 }
00125
00126 template <std::floating_point T>
00127 std::ostream &operator«(std::ostream &ost, const BoundBox<T> &bb)
00128 {
00129   ost « "BB: {\\n";
00130   ost « "  x: [" « bb.minX « "; " « bb.maxX « "],\\n";
00131   ost « "  y: [" « bb.minY « "; " « bb.maxY « "],\\n";
00132   ost « "  z: [" « bb.minZ « "; " « bb.maxZ « "]\\n}";
00133   return ost;
00134 }
00135
00136 } // namespace geom
00137
00138 #endif // __INCLUDE_PRIMITIVES_BOUNDBOX_HH__
```

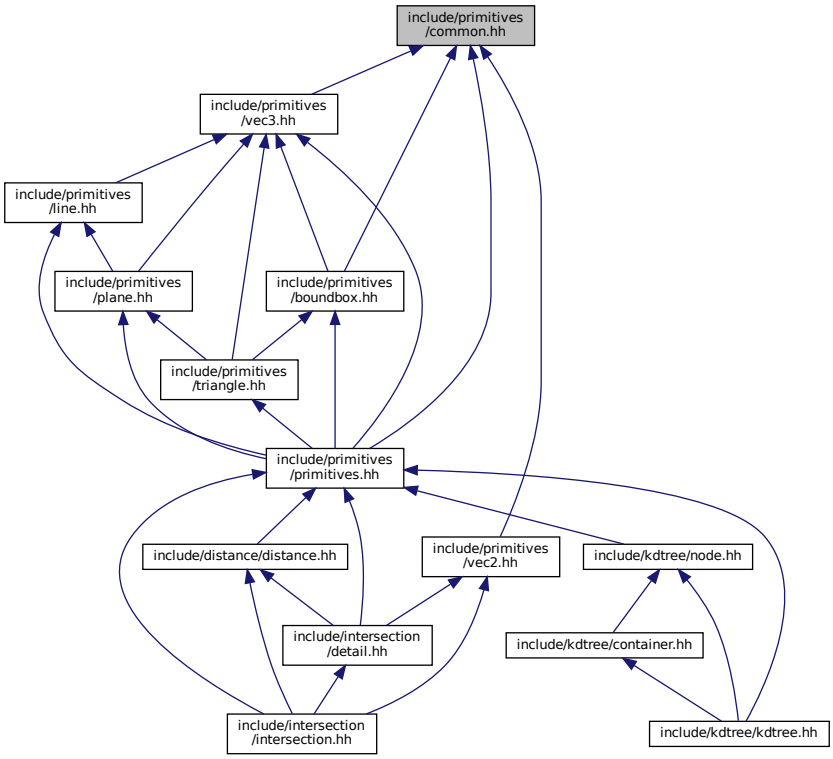
6.15 include/primitives/common.hh File Reference

```
#include <cmath>
#include <concepts>
#include <cstdint>
#include <limits>
```

Include dependency graph for common.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::ThresComp< T >

Namespaces

- geom

  line.hh Line class implementation

Enumerations

- enum geom::Axis : std::int8_t { geom::Axis::X = 0, geom::Axis::Y = 1, geom::Axis::Z = 2, geom::Axis::NONE }

Functions

- template<Number T>
  bool geom::isEqualThreshold (T num1, T num2)
- template<Number T>
  bool geom::isZeroThreshold (T num)

Variables

- template<class T >
  concept geom::Number = std::is_floating_point_v<T> || std::is_integral_v<T>

  Useful concept which represents floating point and integral types.

6.16 common.hh

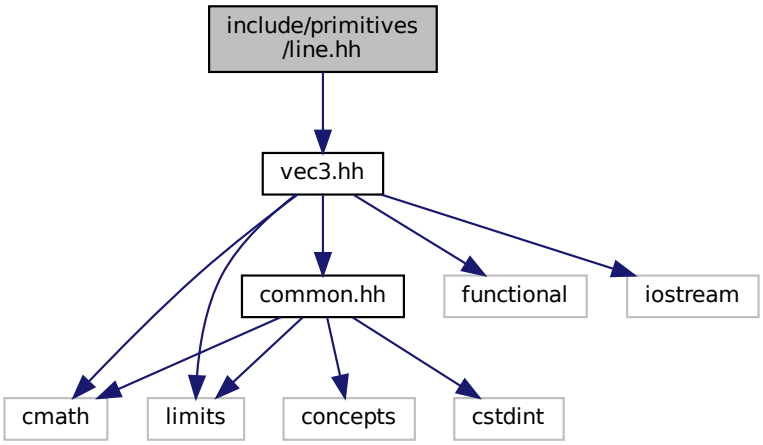
```
00001 #ifndef __INCLUDE_PRIMITIVES_COMMON_HH__
00002 #define __INCLUDE_PRIMITIVES_COMMON_HH__
00003
00004 #include <cmath>
00005 #include <concepts>
00006 #include <cstdint>
00007 #include <limits>
00008 namespace geom
00009 {
00010 /**
00011  * @concept Number
00012  * @brief Useful concept which represents floating point and integral types
00013  *
00014  * @tparam T
00015  */
00016 template <class T>
00017 concept Number = std::is_floating_point_v<T> || std::is_integral_v<T>;
00018
00019 enum class Axis : std::int8_t
00020 {
00021   X = 0,
00022   Y = 1,
00023   Z = 2,
00024   NONE
00025 };
00026
00027 template <Number T>
00028 class ThresComp final
00029 {
00030 private:
00031   static inline T threshold_ = 1e2 * std::numeric_limits<T>::epsilon();
00032
00033 public:
00034   ThresComp() = delete;
00035
00036   static void setThreshold(T thres) requires std::is_floating_point_v<T>
00037   {
00038     threshold_ = thres;
00039   }
00040
00041   static T getThreshold() requires std::is_floating_point_v<T>
00042   {
```

```
00043     return threshold_;
00044   }
00045
00046   static void scaleThreshold(T factor) requires std::is_floating_point_v<T>
00047   {
00048     threshold_ *= factor;
00049   }
00050
00051   static void resetThreshold() requires std::is_floating_point_v<T>
00052   {
00053     threshold_ = std::numeric_limits<T>::epsilon();
00054   }
00055
00056   static bool isEqual(T lhs, T rhs)
00057   {
00058     if constexpr (std::is_floating_point_v<T>)
00059       return std::abs(rhs - lhs) < threshold_;
00060     else
00061       return lhs == rhs;
00062   }
00063
00064   static bool isZero(T num)
00065   {
00066     return isEqual(num, T{});
00067   }
00068 };
00069
00070 template <Number T>
00071 bool isEqualThreshold(T num1, T num2)
00072 {
00073   return ThresComp<T>::isEqual(num1, num2);
00074 }
00075
00076 template <Number T>
00077 bool isZeroThreshold(T num)
00078 {
00079   return ThresComp<T>::isZero(num);
00080 }
00081
00082 } // namespace geom
00083
00084 #endif // __INCLUDE_PRIMITIVES_COMMON_HH__
```

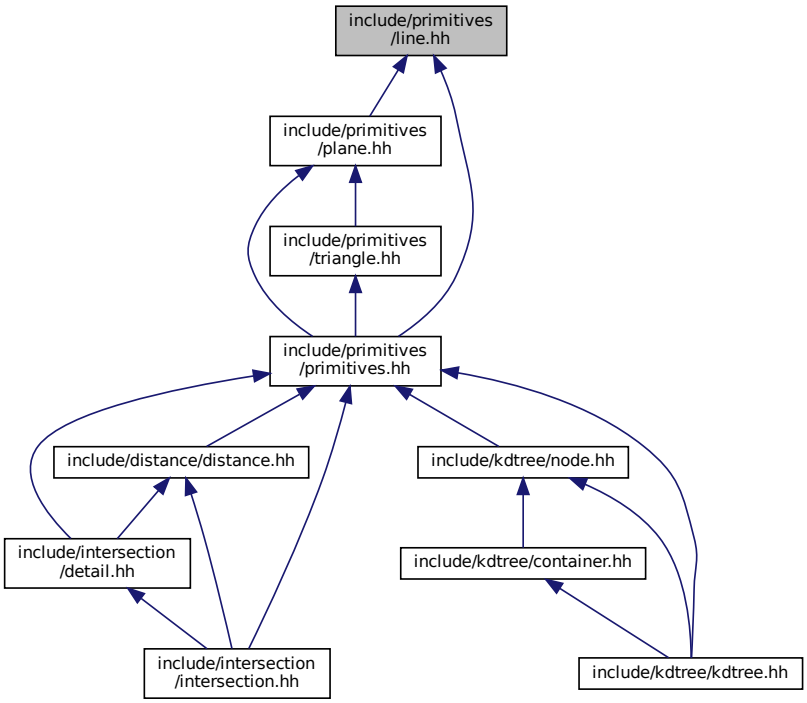
6.17 include/primitives/line.hh File Reference

`#include "vec3.hh"`

Include dependency graph for line.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Line< T >

  Line class implementation.

Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Line< T > &line)

  Line print operator.

6.18 line.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_LINE_HH__
00002 #define __INCLUDE_PRIMITIVES_LINE_HH__
00003
00004 #include "vec3.hh"
00005
00006 /**
00007  * @brief line.hh
00008  * Line class implementation
00009  */
00010
00011 namespace geom
00012 {
00013
00014 /**
00015  * @class Line
00016  * @brief Line class implementation
00017  *
00018  * @tparam T - floating point type of coordinates
00019  */
00020 template <std::floating_point T>
00021 class Line final
00022 {
00023 private:
00024   /**
00025    * @brief Origin and direction vectors
00026    */
00027   Vec3<T> org_{}, dir_{};
00028
00029 public:
00030   /**
00031    * @brief Construct a new Line object
00032    *
00033    * @param[in] org origin vector
00034    * @param[in] dir direction vector
00035    */
00036   Line(const Vec3<T> &org, const Vec3<T> &dir);
00037
00038   /**
00039    * @brief Line equality operator
00040    *
00041    * @tparam T - floating point type of coordinates
00042    * @param[in] rhs 2nd line
00043    * @return true if lines are equal
00044    * @return false if lines are not equal
00045    */
00046   bool operator==(const Line &rhs) const;
00047
00048   /**
00049    * @brief Line inequality operator
00050    *
00051    * @tparam T - floating point type of coordinates
00052    * @param[in] rhs 2nd line
00053    * @return true if lines are not equal
00054    * @return false if lines are equal
00055    */
00056   bool operator!=(const Line &rhs) const;
00057
00058   /**
00059    * @brief Getter for origin vector
00060    *
00061    * @return const Vec3<T>& const reference to origin vector
00062    */
00063   const Vec3<T> &org() const &;
00064
00065   /**
00066    * @brief Getter for direction vector
00067    *
00068    * @return const Vec3<T>& const reference to direction vector
00069    */
00070   const Vec3<T> &dir() const &;
00071
00072   /**
00073    * @brief Getter for origin vector
00074    *
00075    * @return Vec3<T>&& reference to origin vector
00076    */
00077   Vec3<T> &&org() &&;
00078
00079   /**
00080    * @brief Getter for direction vector
00081    *
00082    * @return Vec3<T>&& reference to direction vector
00083    */
00084   Vec3<T> &&dir() &&;
00085
```

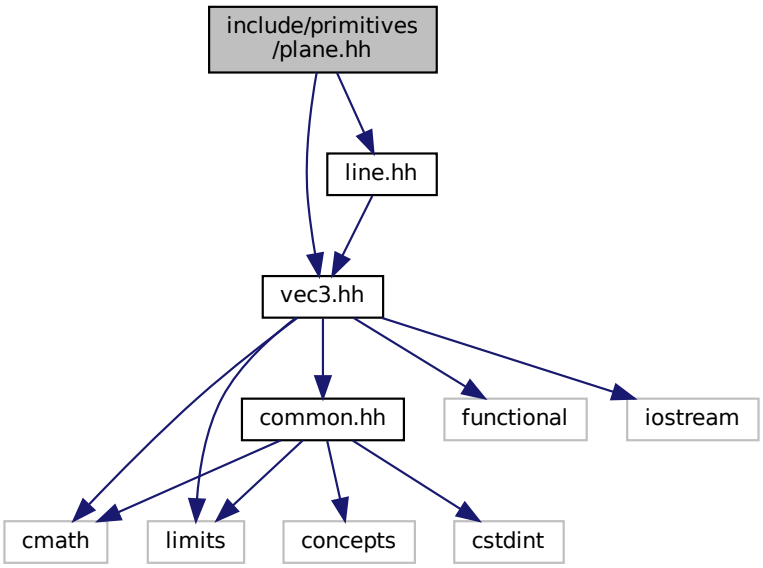
```
00086   /**
00087    * @brief Get point on line by parameter t
00088    *
00089    * @tparam nType numeric type
00090    * @param[in] t point paramater from line's equation
00091    * @return Vec3<T> Point related to parameter
00092    */
00093   template <Number nType>
00094   Vec3<T> getPoint(nType t) const;
00095
00096   /**
00097    * @brief Checks is point belongs to line
00098    *
00099    * @param[in] point const reference to point vector
00100   * @return true if point belongs to line
00101   * @return false if point doesn't belong to line
00102   */
00103   bool belongs(const Vec3<T> &point) const;
00104
00105   /**
00106    * @brief Checks is *this equals to another line
00107    *
00108    * @param[in] line const reference to another line
00109    * @return true if lines are equal
00110    * @return false if lines are not equal
00111    */
00112   bool isEqual(const Line &line) const;
00113
00114   /**
00115    * @brief Checks is *this parallel to another line
00116    * @note Assumes equal lines as parallel
00117    * @param[in] line const reference to another line
00118    * @return true if lines are parallel
00119    * @return false if lines are not parallel
00120    */
00121   bool isPar(const Line &line) const;
00122
00123   /**
00124    * @brief Checks is *this is skew with another line
00125    *
00126    * @param[in] line const reference to another line
00127    * @return true if lines are skew
00128    * @return false if lines are not skew
00129    */
00130   bool isSkew(const Line<T> &line) const;
00131
00132   /**
00133    * @brief Get line by 2 points
00134    *
00135    * @param[in] p1 1st point
00136    * @param[in] p2 2nd point
00137    * @return Line passing through two points
00138    */
00139   static Line getBy2Points(const Vec3<T> &p1, const Vec3<T> &p2);
00140 };
00141
00142 /**
00143  * @brief Line print operator
00144  *
00145  * @tparam T - floating point type of coordinates
00146  * @param[in, out] ost output stream
00147  * @param[in] line Line to print
00148  * @return std::ostream& modified ostream instance
00149  */
00150 template <std::floating_point T>
00151 std::ostream &operator«(std::ostream &ost, const Line<T> &line)
00152 {
00153   ost « line.org() « " + " « line.dir() « " * t";
00154   return ost;
00155 }
00156
00157 template <std::floating_point T>
00158 Line<T>::Line(const Vec3<T> &org, const Vec3<T> &dir) : org_{org}, dir_{dir}
00159 {
00160   if (dir_ == Vec3<T>{0})
00161     throw std::logic_error{"Direction vector equals zero."};
00162 }
00163
00164 template <std::floating_point T>
00165 bool Line<T>::operator==(const Line &rhs) const
00166 {
00167   return isEqual(rhs);
00168 }
00169
00170 template <std::floating_point T>
00171 bool Line<T>::operator!=(const Line &rhs) const
00172 {
```

```
00173   return !operator==(rhs);
00174 }
00175
00176 template <std::floating_point T>
00177 const Vec3<T> &Line<T>::org() const &
00178 {
00179   return org_;
00180 }
00181
00182 template <std::floating_point T>
00183 const Vec3<T> &Line<T>::dir() const &
00184 {
00185   return dir_;
00186 }
00187
00188 template <std::floating_point T>
00189 Vec3<T> &&Line<T>::org() &&
00190 {
00191   return std::move(org_);
00192 }
00193
00194 template <std::floating_point T>
00195 Vec3<T> &&Line<T>::dir() &&
00196 {
00197   return std::move(dir_);
00198 }
00199
00200 template <std::floating_point T>
00201 template <Number nType>
00202 Vec3<T> Line<T>::getPoint(nType t) const
00203 {
00204   return org_ + dir_ * t;
00205 }
00206
00207 template <std::floating_point T>
00208 bool Line<T>::belongs(const Vec3<T> &point) const
00209 {
00210   return dir_.cross(point - org_) == Vec3<T>{0};
00211 }
00212
00213 template <std::floating_point T>
00214 bool Line<T>::isEqual(const Line<T> &line) const
00215 {
00216   return belongs(line.org_) && dir_.isPar(line.dir_);
00217 }
00218
00219 template <std::floating_point T>
00220 bool Line<T>::isPar(const Line<T> &line) const
00221 {
00222   return dir_.isPar(line.dir_);
00223 }
00224
00225 template <std::floating_point T>
00226 bool Line<T>::isSkew(const Line<T> &line) const
00227 {
00228   auto res = triple(line.org_ - org_, dir_, line.dir_);
00229   return !isZeroThreshold(res);
00230 }
00231
00232 template <std::floating_point T>
00233 Line<T> Line<T>::getBy2Points(const Vec3<T> &p1, const Vec3<T> &p2)
00234 {
00235   return Line<T>{p1, p2 - p1};
00236 }
00237
00238 } // namespace geom
00239
00240 #endif // __INCLUDE_PRIMITIVES_LINE_HH__
```

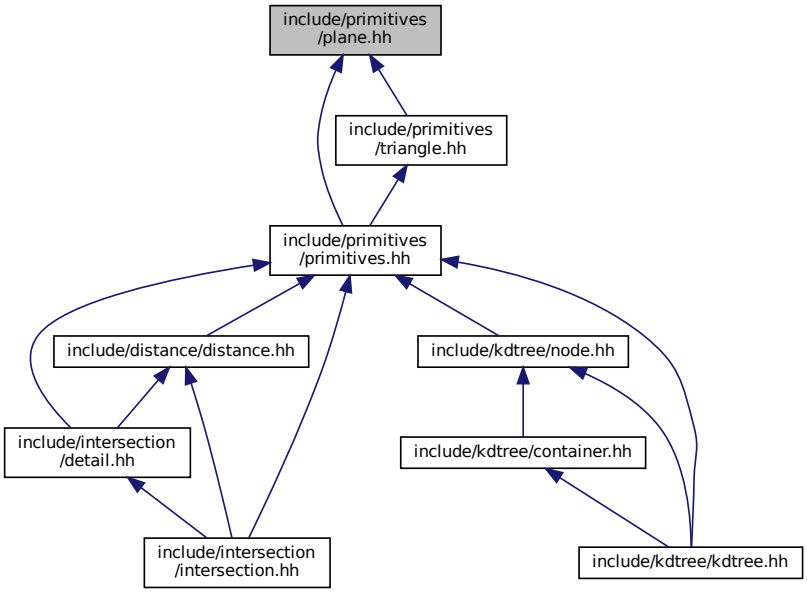
6.19 include/primitives/plane.hh File Reference

```
#include "line.hh"
#include "vec3.hh"
```

Include dependency graph for plane.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Plane< T >

  Plane class realization.

Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Plane< T > &pl)

  Plane print operator.

6.20 plane.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_PLANE_HH__
00002 #define __INCLUDE_PRIMITIVES_PLANE_HH__
00003
00004 #include "line.hh"
00005 #include "vec3.hh"
00006
00007 /**
00008  * @brief
00009  * Plane class implementation
00010  */
00011
00012 namespace geom
00013 {
00014
00015 /**
00016  * @class Plane
00017  * @brief Plane class realization
00018  *
00019  * @tparam T - floating point type of coordinates
00020  */
00021 template <std::floating_point T>
00022 class Plane final
00023 {
00024 private:
00025   /**
00026    * @brief Normal vector, length equals to 1
00027    */
00028   Vec3<T> norm_{};
00029
00030   /**
00031    * @brief Distance from zero to plane
00032    */
00033   T dist_{};
00034
00035   /**
00036    * @brief Construct a new Plane object from normal vector and distance
00037    *
00038    * @param[in] norm normal vector
00039    * @param[in] dist distance from plane to zero
00040    */
00041   Plane(const Vec3<T> &norm, T dist);
00042
00043 public:
00044   /**
00045    * @brief Plane equality operator
00046    *
00047    * @tparam T - floating point type of coordinates
00048    * @param[in] rhs 2nd plane
00049    * @return true if planes are equal
00050    * @return false if planes are not equal
00051    */
00052   bool operator==(const Plane &rhs) const;
00053
00054   /**
00055    * @brief Plane inequality operator
00056    *
00057    * @tparam T - floating point type of coordinates
00058    * @param[in] rhs 2nd plane
00059    * @return true if planes are not equal
00060    * @return false if planes are equal
00061    */
00062   bool operator!=(const Plane &rhs) const;
00063
```

```
00064   /**
00065    * @brief Getter for distance
00066    *
00067    * @return T value of distance
00068    */
00069   T dist() const;
00070
00071   /**
00072    * @brief Getter for normal vector
00073    *
00074    * @return const Vec3<T>& const reference to normal vector
00075    */
00076   const Vec3<T> &norm() const &;
00077
00078   /**
00079    * @brief Getter for normal vector
00080    *
00081    * @return Vec3<T>&& reference to normal vector
00082    */
00083   Vec3<T> &&norm() &&;
00084
00085   /**
00086    * @brief Checks if point belongs to plane
00087    *
00088    * @param[in] point const referene to point vector
00089    * @return true if point belongs to plane
00090    * @return false if point doesn't belong to plane
00091    */
00092   bool belongs(const Vec3<T> &point) const;
00093
00094   /**
00095    * @brief Checks if line belongs to plane
00096    *
00097    * @param[in] line const referene to line
00098    * @return true if line belongs to plane
00099    * @return false if line doesn't belong to plane
00100    */
00101   bool belongs(const Line<T> &line) const;
00102
00103   /**
00104    * @brief Checks is *this equals to another plane
00105    *
00106    * @param[in] rhs const reference to another plane
00107    * @return true if planes are equal
00108    * @return false if planes are not equal
00109    */
00110   bool isEqual(const Plane &rhs) const;
00111
00112   /**
00113    * @brief Checks is *this is parallel to another plane
00114    *
00115    * @param[in] rhs const reference to another plane
00116    * @return true if planes are parallel
00117    * @return false if planes are not parallel
00118    */
00119   bool isPar(const Plane &rhs) const;
00120
00121   /**
00122    * @brief Get plane by 3 points
00123    *
00124    * @param[in] pt1 1st point
00125    * @param[in] pt2 2nd point
00126    * @param[in] pt3 3rd point
00127    * @return Plane passing through three points
00128    */
00129   static Plane getBy3Points(const Vec3<T> &pt1, const Vec3<T> &pt2, const Vec3<T> &pt3);
00130
00131   /**
00132    * @brief Get plane from parametric plane equation
00133    *
00134    * @param[in] org origin vector
00135    * @param[in] dir1 1st direction vector
00136    * @param[in] dir2 2nd direction vector
00137    * @return Plane
00138    */
00139   static Plane getParametric(const Vec3<T> &org, const Vec3<T> &dir1, const Vec3<T> &dir2);
00140
00141   /**
00142    * @brief Get plane from normal point plane equation
00143    *
00144    * @param[in] norm normal vector
00145    * @param[in] point point lying on the plane
00146    * @return Plane
00147    */
00148   static Plane getNormalPoint(const Vec3<T> &norm, const Vec3<T> &point);
00149
00150   /**
```

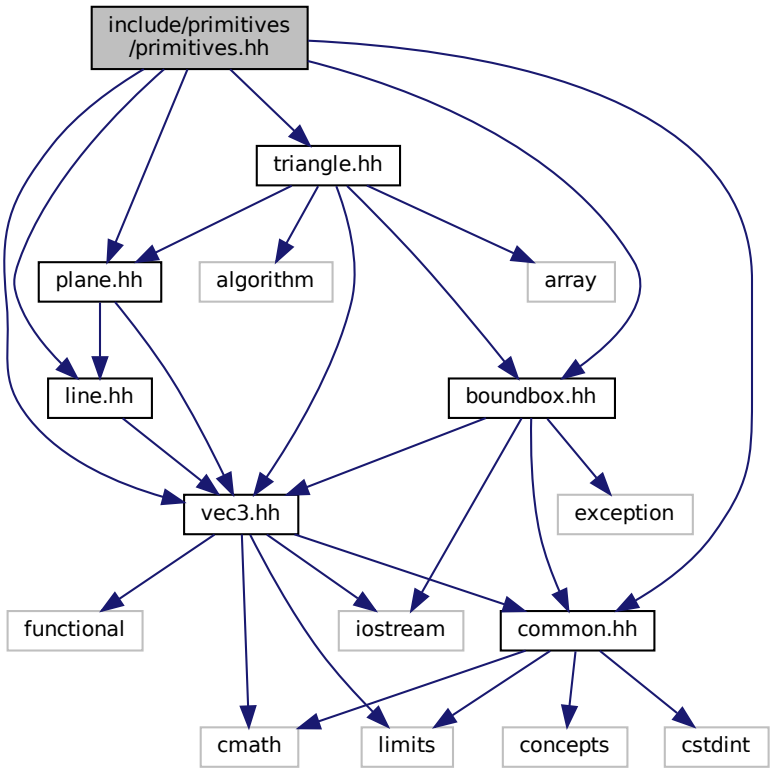
```
00151    * @brief Get plane form normal const plane equation
00152    *
00153    * @param[in] norm normal vector
00154    * @param[in] constant distance
00155    * @return Plane
00156    */
00157   static Plane getNormalDist(const Vec3<T> &norm, T constant);
00158 };
00159
00160 /**
00161  * @brief Plane print operator
00162  *
00163  * @tparam T - floating point type of coordinates
00164  * @param[in, out] ost output stream
00165  * @param[in] pl plane to print
00166  * @return std::ostream& modified ostream instance
00167  */
00168 template <std::floating_point T>
00169 std::ostream &operator«(std::ostream &ost, const Plane<T> &pl)
00170 {
00171   ost « pl.norm() « " * X = " « pl.dist();
00172   return ost;
00173 }
00174
00175 template <std::floating_point T>
00176 Plane<T>::Plane(const Vec3<T> &norm, T dist) : norm_(norm), dist_(dist)
00177 {
00178   if (norm == Vec3<T>{0})
00179     throw std::logic_error{"normal vector equals to zero"};
00180 }
00181
00182 template <std::floating_point T>
00183 bool Plane<T>::operator==(const Plane &rhs) const
00184 {
00185   return isEqual(rhs);
00186 }
00187
00188 template <std::floating_point T>
00189 bool Plane<T>::operator!=(const Plane &rhs) const
00190 {
00191   return !operator==(rhs);
00192 }
00193
00194 template <std::floating_point T>
00195 T Plane<T>::dist() const
00196 {
00197   return dist_;
00198 }
00199
00200 template <std::floating_point T>
00201 const Vec3<T> &Plane<T>::norm() const &
00202 {
00203   return norm_;
00204 }
00205
00206 template <std::floating_point T>
00207 Vec3<T> &&Plane<T>::norm() &&
00208 {
00209   return std::move(norm_);
00210 }
00211
00212 template <std::floating_point T>
00213 bool Plane<T>::belongs(const Vec3<T> &pt) const
00214 {
00215   return isEqualThreshold(norm_.dot(pt), dist_);
00216 }
00217
00218 template <std::floating_point T>
00219 bool Plane<T>::belongs(const Line<T> &line) const
00220 {
00221   return norm_.isPerp(line.dir()) && belongs(line.org());
00222 }
00223
00224 template <std::floating_point T>
00225 bool Plane<T>::isEqual(const Plane &rhs) const
00226 {
00227   return (norm_ * dist_ == rhs.norm_ * rhs.dist_) && (norm_.isPar(rhs.norm_));
00228 }
00229
00230 template <std::floating_point T>
00231 bool Plane<T>::isPar(const Plane &rhs) const
00232 {
00233   return norm_.isPar(rhs.norm_);
00234 }
00235
00236 template <std::floating_point T>
00237 Plane<T> Plane<T>::getBy3Points(const Vec3<T> &pt1, const Vec3<T> &pt2, const Vec3<T> &pt3)
```

```
00238 {
00239   return getParametric(pt1, pt2 - pt1, pt3 - pt1);
00240 }
00241
00242 template <std::floating_point T>
00243 Plane<T> Plane<T>::getParametric(const Vec3<T> &org, const Vec3<T> &dir1, const Vec3<T> &dir2)
00244 {
00245   auto norm = dir1.cross(dir2);
00246   return getNormalPoint(norm, org);
00247 }
00248
00249 template <std::floating_point T>
00250 Plane<T> Plane<T>::getNormalPoint(const Vec3<T> &norm, const Vec3<T> &pt)
00251 {
00252   auto normalized = norm.normalized();
00253   return Plane{normalized, normalized.dot(pt)};
00254 }
00255
00256 template <std::floating_point T>
00257 Plane<T> Plane<T>::getNormalDist(const Vec3<T> &norm, T dist)
00258 {
00259   auto normalized = norm.normalized();
00260   return Plane{normalized, dist};
00261 }
00262
00263 } // namespace geom
00264
00265 #endif // __INCLUDE_PRIMITIVES_PLANE_HH__
```

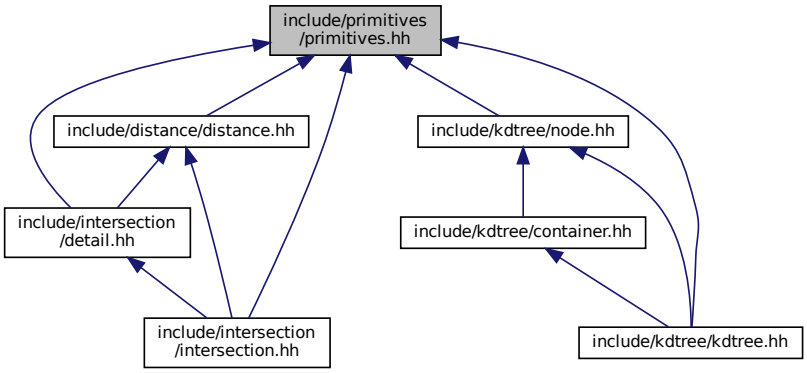
6.21 include/primitives/primitives.hh File Reference

```
#include "boundbox.hh"
#include "common.hh"
#include "line.hh"
#include "plane.hh"
#include "triangle.hh"
#include "vec3.hh"
```

Include dependency graph for primitives.hh:



This graph shows which files directly or indirectly include this file:



6.22 primitives.hh

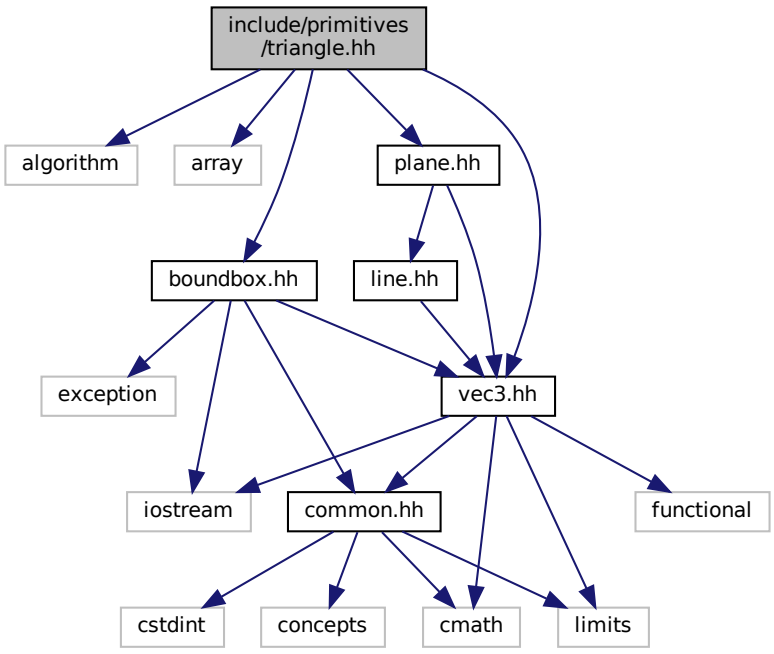
```
00001 #ifndef __INCLUDE_PRIMITIVES_PRIMITIVES_HH__
00002 #define __INCLUDE_PRIMITIVES_PRIMITIVES_HH__
```

```
00003
00004 #include "boundbox.hh"
00005 #include "common.hh"
00006 #include "line.hh"
00007 #include "plane.hh"
00008 #include "triangle.hh"
00009 #include "vec3.hh"
00010
00011 #endif // __INCLUDE_PRIMITIVES_PRIMITIVES_HH__
```

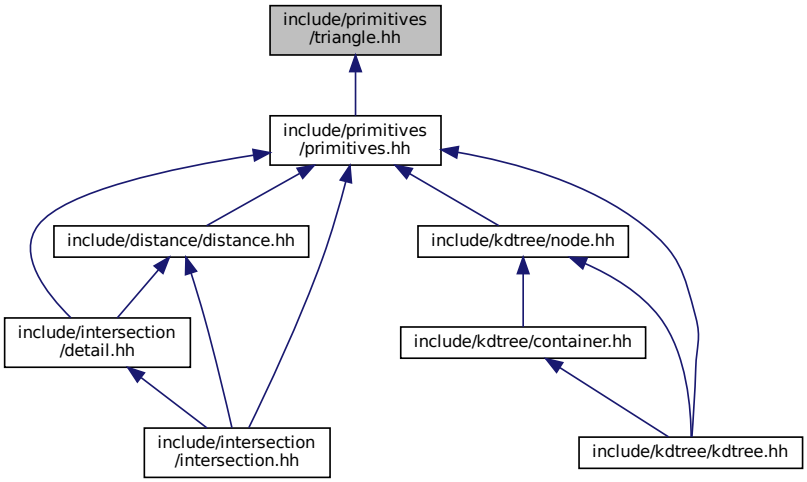
6.23 include/primitives/triangle.hh File Reference

```
#include <algorithm>
#include <array>
#include "boundbox.hh"
#include "plane.hh"
#include "vec3.hh"
```

Include dependency graph for triangle.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Triangle< T >

  Triangle class implementation.

Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Triangle< T > &tr)

  Triangle print operator.
- template<std::floating_point T>
  std::istream & geom::operator>> (std::istream &ist, Triangle< T > &tr)

6.24 triangle.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00002 #define __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00003
00004 #include <algorithm>
00005 #include <array>
00006
00007 #include "boundbox.hh"
00008 #include "plane.hh"
00009 #include "vec3.hh"
00010
00011 /**
00012  * @brief triangle.hh
00013  * Triangle class implementation
```

```
00014  */
00015
00016 namespace geom
00017 {
00018
00019 /**
00020  * @class Triangle
00021  * @brief Triangle class implementation
00022  *
00023  * @tparam T - floating point type of coordinates
00024  */
00025 template <std::floating_point T>
00026 class Triangle final
00027 {
00028 private:
00029   /**
00030    * @brief Vertices of triangle
00031    */
00032   std::array<Vec3<T>, 3> vertices_;
00033
00034 public:
00035   using Iterator = typename std::array<Vec3<T>, 3>::iterator;
00036   using ConstIterator = typename std::array<Vec3<T>, 3>::const_iterator;
00037
00038   /**
00039    * @brief Construct a new Triangle object
00040    */
00041   Triangle();
00042
00043   /**
00044    * @brief Construct a new Triangle object from 3 points
00045    *
00046    * @param[in] p1 1st point
00047    * @param[in] p2 2nd point
00048    * @param[in] p3 3rd point
00049    */
00050   Triangle(const Vec3<T> &p1, const Vec3<T> &p2, const Vec3<T> &p3);
00051
00052   /**
00053    * @brief Overloaded operator[] to get access to vertices
00054    *
00055    * @param[in] idx index of vertex
00056    * @return const Vec3<T>& const reference to vertex
00057    */
00058   const Vec3<T> &operator[](std::size_t idx) const &;
00059
00060   /**
00061    * @brief Overloaded operator[] to get access to vertices
00062    *
00063    * @param[in] idx index of vertex
00064    * @return Vec3<T>&& reference to vertex
00065    */
00066   Vec3<T> &&operator[](std::size_t idx) &&;
00067
00068   /**
00069    * @brief Overloaded operator[] to get access to vertices
00070    *
00071    * @param[in] idx index of vertex
00072    * @return Vec3<T>& reference to vertex
00073    */
00074   Vec3<T> &operator[](std::size_t idx) &;
00075
00076   /**
00077    * @brief Get begin iterator
00078    * @return Iterator
00079    */
00080   Iterator begin() &;
00081
00082   /**
00083    * @brief Get end iterator
00084    * @return Iterator
00085    */
00086   Iterator end() &;
00087
00088   /**
00089    * @brief Get begin const iterator
00090    * @return ConstIterator
00091    */
00092   ConstIterator begin() const &;
00093
00094   /**
00095    * @brief Get end const iterator
00096    * @return ConstIterator
00097    */
00098   ConstIterator end() const &;
00099
00100   /**
```

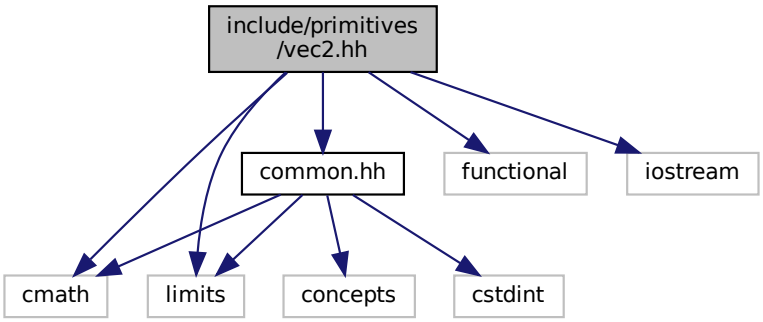
```
00101     * @brief Get triangle's plane
00102     *
00103     * @return Plane<T>
00104     */
00105    Plane<T> getPlane() const;
00106
00107    /**
00108     * @brief Check is triangle valid
00109     *
00110     * @return true if triangle is valid
00111     * @return false if triangle is invalid
00112     */
00113    bool isValid() const;
00114
00115    /**
00116     * @brief Returns triangle's bound box
00117     *
00118     * @return BoundBox<T>
00119     */
00120    BoundBox<T> boundBox() const;
00121
00122    /**
00123     * @brief Checks if this Triangle belongs to BoundBox
00124     *
00125     * @param[in] bb BoundBox
00126     * @return true if Triangle belongs to BoundBox
00127     * @return false if Triangle doesn't belong to BoundBox
00128     */
00129    bool belongsTo(const BoundBox<T> &bb) const;
00130 };
00131
00132 /**
00133  * @brief Triangle print operator
00134  *
00135  * @tparam T - floating point type of coordinates
00136  * @param[in, out] ost output stream
00137  * @param[in] tr Triangle to print
00138  * @return std::ostream& modified ostream instance
00139  */
00140 template <std::floating_point T>
00141 std::ostream &operator«(std::ostream &ost, const Triangle<T> &tr)
00142 {
00143    ost « "Triangle: {";
00144    for (std::size_t i = 0; i < 3; ++i)
00145      ost « tr[i] « (i == 2 ? "" : ", ");
00146
00147    ost « "}";
00148
00149    return ost;
00150 }
00151
00152 template <std::floating_point T>
00153 std::istream &operator»(std::istream &ist, Triangle<T> &tr)
00154 {
00155    ist » tr[0] » tr[1] » tr[2];
00156    return ist;
00157 }
00158
00159 template <std::floating_point T>
00160 Triangle<T>::Triangle() : vertices_()
00161 {}
00162
00163 template <std::floating_point T>
00164 Triangle<T>::Triangle(const Vec3<T> &p1, const Vec3<T> &p2, const Vec3<T> &p3)
00165    : vertices_{p1, p2, p3}
00166 {}
00167
00168 template <std::floating_point T>
00169 const Vec3<T> &Triangle<T>::operator[](std::size_t idx) const &
00170 {
00171    return vertices_[idx % 3];
00172 }
00173
00174 template <std::floating_point T>
00175 Vec3<T> &&Triangle<T>::operator[](std::size_t idx) &&
00176 {
00177    return std::move(vertices_[idx % 3]);
00178 }
00179
00180 template <std::floating_point T>
00181 Vec3<T> &Triangle<T>::operator[](std::size_t idx) &
00182 {
00183    return vertices_[idx % 3];
00184 }
00185
00186 template <std::floating_point T>
00187 typename Triangle<T>::Iterator Triangle<T>::begin() &
```

```
00188 {
00189   return vertices_.begin();
00190 }
00191
00192 template <std::floating_point T>
00193 typename Triangle<T>::Iterator Triangle<T>::end() &
00194 {
00195   return vertices_.end();
00196 }
00197
00198 template <std::floating_point T>
00199 typename Triangle<T>::ConstIterator Triangle<T>::begin() const &
00200 {
00201   return vertices_.begin();
00202 }
00203
00204 template <std::floating_point T>
00205 typename Triangle<T>::ConstIterator Triangle<T>::end() const &
00206 {
00207   return vertices_.end();
00208 }
00209
00210 template <std::floating_point T>
00211 Plane<T> Triangle<T>::getPlane() const
00212 {
00213   return Plane<T>::getBy3Points(vertices_[0], vertices_[1], vertices_[2]);
00214 }
00215
00216 template <std::floating_point T>
00217 bool Triangle<T>::isValid() const
00218 {
00219   auto edge1 = vertices_[1] - vertices_[0];
00220   auto edge2 = vertices_[2] - vertices_[0];
00221
00222   auto cross12 = cross(edge1, edge2);
00223   return (cross12 != Vec3<T>{});
00224 }
00225
00226 template <std::floating_point T>
00227 BoundBox<T> Triangle<T>::boundBox() const
00228 {
00229   auto minMaxX = std::minmax({vertices_[0].x, vertices_[1].x, vertices_[2].x});
00230   auto minMaxY = std::minmax({vertices_[0].y, vertices_[1].y, vertices_[2].y});
00231   auto minMaxZ = std::minmax({vertices_[0].z, vertices_[1].z, vertices_[2].z});
00232
00233   return {
00234     minMaxX.first - ThresComp<T>::getThreshold(), minMaxX.second + ThresComp<T>::getThreshold(),
00235     minMaxY.first - ThresComp<T>::getThreshold(), minMaxY.second + ThresComp<T>::getThreshold(),
00236     minMaxZ.first - ThresComp<T>::getThreshold(), minMaxZ.second + ThresComp<T>::getThreshold()};
00237 }
00238
00239 template <std::floating_point T>
00240 bool Triangle<T>::belongsTo(const BoundBox<T> &bb) const
00241 {
00242   return boundBox().belongsTo(bb);
00243 }
00244
00245 } // namespace geom
00246
00247 #endif // __INCLUDE_PRIMITIVES_TRIANGLE_HH__
```

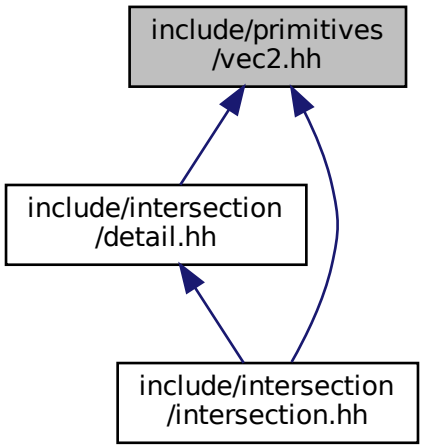
6.25 include/primitives/vec2.hh File Reference

```
#include <cmath>
#include <functional>
#include <iostream>
#include <limits>
#include "common.hh"
```

Include dependency graph for vec2.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Vec2< T >

  Vec2 class realization.

Namespaces

- geom

  line.hh Line class implementation

Typedefs

- using geom::Vec2D = Vec2< double >
- using geom::Vec2F = Vec2< float >

Functions

- template<std::floating_point T>
  Vec2< T > geom::operator+ (const Vec2< T > &lhs, const Vec2< T > &rhs)

  Overloaded + operator.
- template<std::floating_point T>
  Vec2< T > geom::operator- (const Vec2< T > &lhs, const Vec2< T > &rhs)

  Overloaded - operator.
- template<Number nT, std::floating_point T>
  Vec2< T > geom::operator* (const nT &val, const Vec2< T > &rhs)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec2< T > geom::operator* (const Vec2< T > &lhs, const nT &val)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec2< T > geom::operator/ (const Vec2< T > &lhs, const nT &val)

  Overloaded divide by value operator.
- template<std::floating_point T>
  T geom::dot (const Vec2< T > &lhs, const Vec2< T > &rhs)

  Dot product function.
- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Vec2< T > &vec)

  Vec2 print operator.

6.25.1 Detailed Description

Vec2 class implementation

Definition in file vec2.hh.

6.26 vec2.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_VEC2_HH__
00002 #define __INCLUDE_PRIMITIVES_VEC2_HH__
00003
00004 #include <cmath>
00005 #include <functional>
00006 #include <iostream>
00007 #include <limits>
00008
00009 #include "common.hh"
00010
00011 /**
00012  * @file vec2.hh
00013  * Vec2 class implementation
00014  */
00015
00016 namespace geom
00017 {
00018
00019 /**
00020  * @class Vec2
00021  * @brief Vec2 class realization
00022  *
```

```
00023  * @tparam T - floating point type of coordinates
00024  */
00025 template <std::floating_point T>
00026 struct Vec2 final
00027 {
00028   /**
00029    * @brief Vec2 coordinates
00030    */
00031   T x{}, y{};
00032
00033   /**
00034    * @brief Construct a new Vec2 object from 3 coordinates
00035    *
00036    * @param[in] coordX x coordinate
00037    * @param[in] coordY y coordinate
00038    */
00039   Vec2(T coordX, T coordY) : x(coordX), y(coordY)
00040   {}
00041
00042   /**
00043    * @brief Construct a new Vec2 object with equals coordinates
00044    *
00045    * @param[in] coordX coordinate (default to {})
00046    */
00047   explicit Vec2(T coordX = {}) : Vec2(coordX, coordX)
00048   {}
00049
00050   /**
00051    * @brief Vec2 equality operator
00052    *
00053    * @tparam T vector template parameter
00054    * @param[in] rhs second vector
00055    * @return true if vectors are equal
00056    * @return false otherwise
00057    */
00058   bool operator==(const Vec2 &rhs) const;
00059
00060   /**
00061    * @brief Vec2 equality operator
00062    *
00063    * @tparam T vector template parameter
00064    * @param[in] rhs second vector
00065    * @return true if vectors are not equal
00066    * @return false otherwise
00067    */
00068   bool operator!=(const Vec2 &rhs) const;
00069
00070   /**
00071    * @brief Overloaded += operator
00072    * Increments vector coordinates by corresponding coordinates of vec
00073    * @param[in] vec vector to incremented with
00074    * @return Vec2& reference to current instance
00075    */
00076   Vec2 &operator+=(const Vec2 &vec);
00077
00078   /**
00079    * @brief Overloaded -= operator
00080    * Decrements vector coordinates by corresponding coordinates of vec
00081    * @param[in] vec vector to decremented with
00082    * @return Vec2& reference to current instance
00083    */
00084   Vec2 &operator-=(const Vec2 &vec);
00085
00086   /**
00087    * @brief Unary - operator
00088    *
00089    * @return Vec2 negated Vec2 instance
00090    */
00091   Vec2 operator-() const;
00092
00093   /**
00094    * @brief Overloaded *= by number operator
00095    *
00096    * @tparam nType numeric type of value to multiply by
00097    * @param[in] val value to multiply by
00098    * @return Vec2& reference to vector instance
00099    */
00100   template <Number nType>
00101   Vec2 &operator*=(nType val);
00102
00103   /**
00104    * @brief Overloaded /= by number operator
00105    *
00106    * @tparam nType numeric type of value to divide by
00107    * @param[in] val value to divide by
00108    * @return Vec2& reference to vector instance
00109    *
```

```
00110    * @warning Does not check if val equals 0
00111    */
00112   template <Number nType>
00113   Vec2 &operator/=(nType val);
00114
00115   /**
00116    * @brief Dot product function
00117    *
00118    * @param rhs vector to dot product with
00119    * @return T dot product of two vectors
00120    */
00121   T dot(const Vec2 &rhs) const;
00122
00123   /**
00124    * @brief Calculate squared length of a vector function
00125    *
00126    * @return T length^2
00127    */
00128   T length2() const;
00129
00130   /**
00131    * @brief Calculate length of a vector function
00132    *
00133    * @return T length
00134    */
00135   T length() const;
00136
00137   /**
00138    * @brief Get the perpendicular to this vector
00139    *
00140    * @return Vec2 perpendicular vector
00141    */
00142   Vec2 getPerp() const;
00143
00144   /**
00145    * @brief Get normalized vector function
00146    *
00147    * @return Vec2 normalized vector
00148    */
00149   Vec2 normalized() const;
00150
00151   /**
00152    * @brief Normalize vector function
00153    *
00154    * @return Vec2& reference to instance
00155    */
00156   Vec2 &normalize() &;
00157
00158   /**
00159    * @brief Overloaded operator [] (non-const version)
00160    * To get access to coordinates
00161    * @param i index of coordinate (0 - x, 1 - y)
00162    * @return T& reference to coordinate value
00163    *
00164    * @note Coordinates calculated by mod 2
00165    */
00166   T &operator[](std::size_t i) &;
00167
00168   /**
00169    * @brief Overloaded operator [] (const version)
00170    * To get access to coordinates
00171    * @param i index of coordinate (0 - x, 1 - y)
00172    * @return T coordinate value
00173    *
00174    * @note Coordinates calculated by mod 2
00175    */
00176   T operator[](std::size_t i) const &;
00177
00178   /**
00179    * @brief Overloaded operator [] (const version)
00180    * To get access to coordinates
00181    * @param i index of coordinate (0 - x, 1 - y)
00182    * @return T coordinate value
00183    *
00184    * @note Coordinates calculated by mod 2
00185    */
00186   T &&operator[](std::size_t i) &&;
00187
00188   /**
00189    * @brief Check if vector is parallel to another
00190    *
00191    * @param[in] rhs vector to check parallelism with
00192    * @return true if vector is parallel
00193    * @return false otherwise
00194    */
00195   bool isPar(const Vec2 &rhs) const;
00196
```

```
00197   /**
00198    * @brief Check if vector is perpendicular to another
00199    *
00200    * @param[in] rhs vector to check perpendicularity with
00201    * @return true if vector is perpendicular
00202    * @return false otherwise
00203    */
00204   bool isPerp(const Vec2 &rhs) const;
00205
00206   /**
00207    * @brief Check if vector is equal to another
00208    *
00209    * @param[in] rhs vector to check equality with
00210    * @return true if vector is equal
00211    * @return false otherwise
00212    */
00213   bool isEqual(const Vec2 &rhs) const;
00214 };
00215
00216 /**
00217  * @brief Overloaded + operator
00218  *
00219  * @tparam T vector template parameter
00220  * @param[in] lhs first vector
00221  * @param[in] rhs second vector
00222  * @return Vec2<T> sum of two vectors
00223  */
00224 template <std::floating_point T>
00225 Vec2<T> operator+(const Vec2<T> &lhs, const Vec2<T> &rhs)
00226 {
00227   Vec2<T> res{lhs};
00228   res += rhs;
00229   return res;
00230 }
00231
00232 /**
00233  * @brief Overloaded - operator
00234  *
00235  * @tparam T vector template parameter
00236  * @param[in] lhs first vector
00237  * @param[in] rhs second vector
00238  * @return Vec2<T> res of two vectors
00239  */
00240 template <std::floating_point T>
00241 Vec2<T> operator-(const Vec2<T> &lhs, const Vec2<T> &rhs)
00242 {
00243   Vec2<T> res{lhs};
00244   res -= rhs;
00245   return res;
00246 }
00247
00248 /**
00249  * @brief Overloaded multiple by value operator
00250  *
00251  * @tparam nT type of value to multiply by
00252  * @tparam T vector template parameter
00253  * @param[in] val value to multiply by
00254  * @param[in] rhs vector to multiply by value
00255  * @return Vec2<T> result vector
00256  */
00257 template <Number nT, std::floating_point T>
00258 Vec2<T> operator*(const nT &val, const Vec2<T> &rhs)
00259 {
00260   Vec2<T> res{rhs};
00261   res *= val;
00262   return res;
00263 }
00264
00265 /**
00266  * @brief Overloaded multiple by value operator
00267  *
00268  * @tparam nT type of value to multiply by
00269  * @tparam T vector template parameter
00270  * @param[in] val value to multiply by
00271  * @param[in] lhs vector to multiply by value
00272  * @return Vec2<T> result vector
00273  */
00274 template <Number nT, std::floating_point T>
00275 Vec2<T> operator*(const Vec2<T> &lhs, const nT &val)
00276 {
00277   Vec2<T> res{lhs};
00278   res *= val;
00279   return res;
00280 }
00281
00282 /**
00283  * @brief Overloaded divide by value operator
```

```
00284  *
00285  * @tparam nT type of value to divide by
00286  * @tparam T vector template parameter
00287  * @param[in] val value to divide by
00288  * @param[in] lhs vector to divide by value
00289  * @return Vec2<T> result vector
00290  */
00291 template <Number nT, std::floating_point T>
00292 Vec2<T> operator/(const Vec2<T> &lhs, const nT &val)
00293 {
00294   Vec2<T> res{lhs};
00295   res /= val;
00296   return res;
00297 }
00298
00299 /**
00300  * @brief Dot product function
00301  *
00302  * @tparam T vector template parameter
00303  * @param[in] lhs first vector
00304  * @param[in] rhs second vector
00305  * @return T dot production
00306  */
00307 template <std::floating_point T>
00308 T dot(const Vec2<T> &lhs, const Vec2<T> &rhs)
00309 {
00310   return lhs.dot(rhs);
00311 }
00312
00313 /**
00314  * @brief Vec2 print operator
00315  *
00316  * @tparam T vector template parameter
00317  * @param[in, out] ost output stream
00318  * @param[in] vec vector to print
00319  * @return std::ostream& modified stream instance
00320  */
00321 template <std::floating_point T>
00322 std::ostream &operator«(std::ostream &ost, const Vec2<T> &vec)
00323 {
00324   ost « "(" « vec.x « ", " « vec.y « ")";
00325   return ost;
00326 }
00327
00328 using Vec2D = Vec2<double>;
00329 using Vec2F = Vec2<float>;
00330
00331 template <std::floating_point T>
00332 bool Vec2<T>::operator==(const Vec2 &rhs) const
00333 {
00334   return isEqual(rhs);
00335 }
00336
00337 template <std::floating_point T>
00338 bool Vec2<T>::operator!=(const Vec2 &rhs) const
00339 {
00340   return !operator==(rhs);
00341 }
00342
00343 template <std::floating_point T>
00344 Vec2<T> &Vec2<T>::operator+=(const Vec2 &vec)
00345 {
00346   x += vec.x;
00347   y += vec.y;
00348
00349   return *this;
00350 }
00351
00352 template <std::floating_point T>
00353 Vec2<T> &Vec2<T>::operator-=(const Vec2 &vec)
00354 {
00355   x -= vec.x;
00356   y -= vec.y;
00357
00358   return *this;
00359 }
00360
00361 template <std::floating_point T>
00362 Vec2<T> Vec2<T>::operator-() const
00363 {
00364   return Vec2{-x, -y};
00365 }
00366
00367 template <std::floating_point T>
00368 template <Number nType>
00369 Vec2<T> &Vec2<T>::operator*=(nType val)
00370 {
```

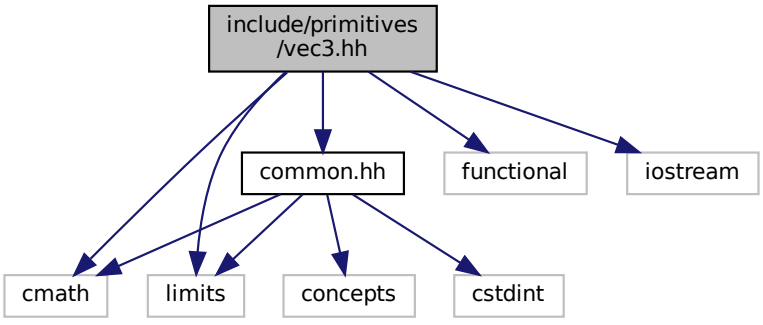
```
00371   x *= val;
00372   y *= val;
00373
00374   return *this;
00375 }
00376
00377 template <std::floating_point T>
00378 template <Number nType>
00379 Vec2<T> &Vec2<T>::operator/=(nType val)
00380 {
00381   x /= static_cast<T>(val);
00382   y /= static_cast<T>(val);
00383
00384   return *this;
00385 }
00386
00387 template <std::floating_point T>
00388 T Vec2<T>::dot(const Vec2 &rhs) const
00389 {
00390   return x * rhs.x + y * rhs.y;
00391 }
00392
00393 template <std::floating_point T>
00394 T Vec2<T>::length2() const
00395 {
00396   return dot(*this);
00397 }
00398
00399 template <std::floating_point T>
00400 T Vec2<T>::length() const
00401 {
00402   return std::sqrt(length2());
00403 }
00404
00405 template <std::floating_point T>
00406 Vec2<T> Vec2<T>::getPerp() const
00407 {
00408   return {y, -x};
00409 }
00410
00411 template <std::floating_point T>
00412 Vec2<T> Vec2<T>::normalized() const
00413 {
00414   Vec2 res{*this};
00415   res.normalize();
00416   return res;
00417 }
00418
00419 template <std::floating_point T>
00420 Vec2<T> &Vec2<T>::normalize() &
00421 {
00422   T len2 = length2();
00423   if (isZeroThreshold(len2) || isEqualThreshold(len2, T{1}))
00424     return *this;
00425   return *this /= std::sqrt(len2);
00426 }
00427
00428 template <std::floating_point T>
00429 T &Vec2<T>::operator[](std::size_t i) &
00430 {
00431   switch (i % 2)
00432   {
00433   case 0:
00434     return x;
00435   case 1:
00436     return y;
00437   default:
00438     throw std::logic_error{"Impossible case in operator[]\n"};
00439   }
00440 }
00441
00442 template <std::floating_point T>
00443 T Vec2<T>::operator[](std::size_t i) const &
00444 {
00445   switch (i % 2)
00446   {
00447   case 0:
00448     return x;
00449   case 1:
00450     return y;
00451   default:
00452     throw std::logic_error{"Impossible case in operator[]\n"};
00453   }
00454 }
00455
00456 template <std::floating_point T>
00457 T &&Vec2<T>::operator[](std::size_t i) &&
```

```
00458 {
00459   switch (i % 2)
00460   {
00461   case 0:
00462     return std::move(x);
00463   case 1:
00464     return std::move(y);
00465   default:
00466     throw std::logic_error{"Impossible case in operator[]\n"};
00467   }
00468 }
00469
00470 template <std::floating_point T>
00471 bool Vec2<T>::isPar(const Vec2 &rhs) const
00472 {
00473   auto det = x * rhs.y - rhs.x * y;
00474   return isZeroThreshold(det);
00475 }
00476
00477 template <std::floating_point T>
00478 bool Vec2<T>::isPerp(const Vec2 &rhs) const
00479 {
00480   return isZeroThreshold(dot(rhs));
00481 }
00482
00483 template <std::floating_point T>
00484 bool Vec2<T>::isEqual(const Vec2 &rhs) const
00485 {
00486   return isEqualThreshold(x, rhs.x) && isEqualThreshold(y, rhs.y);
00487 }
00488
00489 } // namespace geom
00490
00491 #endif // __INCLUDE_PRIMITIVES_VEC2_HH__
```

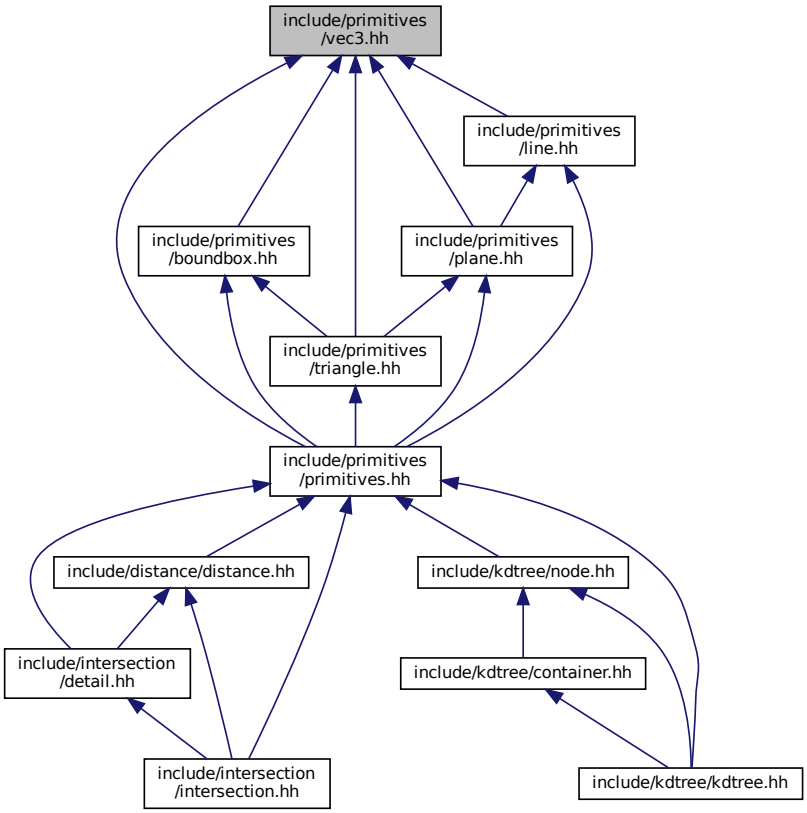
6.27 include/primitives/vec3.hh File Reference

```
#include <cmath>
#include <functional>
#include <iostream>
#include <limits>
#include "common.hh"
```

Include dependency graph for vec3.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Vec3< T >

  Vec3 class realization.

Namespaces

- geom

  line.hh Line class implementation

Typedefs

- using geom::Vec3D = Vec3< double >
- using geom::Vec3F = Vec3< float >

Functions

- template<std::floating_point T>
  Vec3< T > geom::operator+ (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Overloaded + operator.
- template<std::floating_point T>
  Vec3< T > geom::operator- (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Overloaded - operator.
- template<Number nT, std::floating_point T>
  Vec3< T > geom::operator* (const nT &val, const Vec3< T > &rhs)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec3< T > geom::operator* (const Vec3< T > &lhs, const nT &val)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vec3< T > geom::operator/ (const Vec3< T > &lhs, const nT &val)

  Overloaded divide by value operator.
- template<std::floating_point T>
  T geom::dot (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Dot product function.
- template<std::floating_point T>
  Vec3< T > geom::cross (const Vec3< T > &lhs, const Vec3< T > &rhs)

  Cross product function.
- template<std::floating_point T>
  T geom::triple (const Vec3< T > &v1, const Vec3< T > &v2, const Vec3< T > &v3)

  Triple product function.
- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Vec3< T > &vec)

  Vec3 print operator.
- template<std::floating_point T>
  std::istream & geom::operator>> (std::istream &ist, Vec3< T > &vec)

  Vec3 scan operator.

6.27.1 Detailed Description

Vec3 class implementation

Definition in file vec3.hh.

6.28 vec3.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_VEC3_HH__
00002 #define __INCLUDE_PRIMITIVES_VEC3_HH__
00003
00004 #include <cmath>
00005 #include <functional>
00006 #include <iostream>
00007 #include <limits>
00008
00009 #include "common.hh"
00010
00011 /**
00012  * @file vec3.hh
00013  * Vec3 class implementation
00014  */
00015
00016 namespace geom
```

```
00017 {
00018
00019 /**
00020  * @class Vec3
00021  * @brief Vec3 class realization
00022  *
00023  * @tparam T - floating point type of coordinates
00024  */
00025 template <std::floating_point T>
00026 struct Vec3 final
00027 {
00028   /**
00029    * @brief Vec3 coordinates
00030    */
00031   T x{}, y{}, z{};
00032
00033   /**
00034    * @brief Construct a new Vec3 object from 3 coordinates
00035    *
00036    * @param[in] coordX x coordinate
00037    * @param[in] coordY y coordinate
00038    * @param[in] coordZ z coordinate
00039    */
00040   Vec3(T coordX, T coordY, T coordZ) : x(coordX), y(coordY), z(coordZ)
00041   {}
00042
00043   /**
00044    * @brief Construct a new Vec3 object with equals coordinates
00045    *
00046    * @param[in] coordX coordinate (default to {})
00047    */
00048   explicit Vec3(T coordX = {}) : Vec3(coordX, coordX, coordX)
00049   {}
00050
00051   /**
00052    * @brief Vec3 equality operator
00053    *
00054    * @tparam T vector template parameter
00055    * @param[in] rhs second vector
00056    * @return true if vectors are equal
00057    * @return false otherwise
00058    */
00059   bool operator==(const Vec3 &rhs) const;
00060
00061   /**
00062    * @brief Vec3 inequality operator
00063    *
00064    * @tparam T vector template parameter
00065    * @param[in] rhs second vector
00066    * @return true if vectors are not equal
00067    * @return false otherwise
00068    */
00069   bool operator!=(const Vec3 &rhs) const;
00070
00071   /**
00072    * @brief Overloaded += operator
00073    * Increments vector coordinates by corresponding coordinates of vec
00074    * @param[in] vec vector to incremented with
00075    * @return Vec3& reference to current instance
00076    */
00077   Vec3 &operator+=(const Vec3 &vec);
00078
00079   /**
00080    * @brief Overloaded -= operator
00081    * Decrements vector coordinates by corresponding coordinates of vec
00082    * @param[in] vec vector to decremented with
00083    * @return Vec3& reference to current instance
00084    */
00085   Vec3 &operator-=(const Vec3 &vec);
00086
00087   /**
00088    * @brief Unary - operator
00089    *
00090    * @return Vec3 negated Vec3 instance
00091    */
00092   Vec3 operator-() const;
00093
00094   /**
00095    * @brief Overloaded *= by number operator
00096    *
00097    * @tparam nType numeric type of value to multiply by
00098    * @param[in] val value to multiply by
00099    * @return Vec3& reference to vector instance
00100    */
00101   template <Number nType>
00102   Vec3 &operator*=(nType val);
00103
```

```
00104   /**
00105    * @brief Overloaded /= by number operator
00106    *
00107    * @tparam nType numeric type of value to divide by
00108    * @param[in] val value to divide by
00109    * @return Vec3& reference to vector instance
00110    *
00111    * @warning Does not check if val equals 0
00112    */
00113   template <Number nType>
00114   Vec3 &operator/=(nType val);
00115
00116   /**
00117    * @brief Dot product function
00118    *
00119    * @param rhs vector to dot product with
00120    * @return T dot product of two vectors
00121    */
00122   T dot(const Vec3 &rhs) const;
00123
00124   /**
00125    * @brief Cross product function
00126    *
00127    * @param rhs vector to cross product with
00128    * @return Vec3 cross product of two vectors
00129    */
00130   Vec3 cross(const Vec3 &rhs) const;
00131
00132   /**
00133    * @brief Calculate squared length of a vector function
00134    *
00135    * @return T length^2
00136    */
00137   T length2() const;
00138
00139   /**
00140    * @brief Calculate length of a vector function
00141    *
00142    * @return T length
00143    */
00144   T length() const;
00145
00146   /**
00147    * @brief Get normalized vector function
00148    *
00149    * @return Vec3 normalized vector
00150    */
00151   Vec3 normalized() const;
00152
00153   /**
00154    * @brief Normalize vector function
00155    *
00156    * @return Vec3& reference to instance
00157    */
00158   Vec3 &normalize() &;
00159
00160   /**
00161    * @brief Overloaded operator [] (non-const version)
00162    * To get access to coordinates
00163    * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00164    * @return T& reference to coordinate value
00165    *
00166    * @note Coordinates calculated by mod 3
00167    */
00168   T &operator[](std::size_t i) &;
00169
00170   /**
00171    * @brief Overloaded operator [] (const version)
00172    * To get access to coordinates
00173    * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00174    * @return T coordinate value
00175    *
00176    * @note Coordinates calculated by mod 3
00177    */
00178   T operator[](std::size_t i) const &;
00179
00180   /**
00181    * @brief Overloaded operator [] (rvalue `this` version)
00182    * To get access to coordinates
00183    * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00184    * @return T coordinate value
00185    *
00186    * @note Coordinates calculated by mod 3
00187    */
00188   T &&operator[](std::size_t i) &&;
00189
00190   /**
```

```
00191     * @brief Check if vector is parallel to another
00192     *
00193     * @param[in] rhs vector to check parallelism with
00194     * @return true if vector is parallel
00195     * @return false otherwise
00196     */
00197   bool isPar(const Vec3 &rhs) const;
00198
00199   /**
00200     * @brief Check if vector is perpendicular to another
00201     *
00202     * @param[in] rhs vector to check perpendicularity with
00203     * @return true if vector is perpendicular
00204     * @return false otherwise
00205     */
00206   bool isPerp(const Vec3 &rhs) const;
00207
00208   /**
00209     * @brief Check if vector is equal to another
00210     *
00211     * @param[in] rhs vector to check equality with
00212     * @return true if vector is equal
00213     * @return false otherwise
00214     */
00215   bool isEqual(const Vec3 &rhs) const;
00216 };
00217
00218 /**
00219  * @brief Overloaded + operator
00220  *
00221  * @tparam T vector template parameter
00222  * @param[in] lhs first vector
00223  * @param[in] rhs second vector
00224  * @return Vec3<T> sum of two vectors
00225  */
00226 template <std::floating_point T>
00227 Vec3<T> operator+(const Vec3<T> &lhs, const Vec3<T> &rhs)
00228 {
00229   Vec3<T> res{lhs};
00230   res += rhs;
00231   return res;
00232 }
00233
00234 /**
00235  * @brief Overloaded - operator
00236  *
00237  * @tparam T vector template parameter
00238  * @param[in] lhs first vector
00239  * @param[in] rhs second vector
00240  * @return Vec3<T> res of two vectors
00241  */
00242 template <std::floating_point T>
00243 Vec3<T> operator-(const Vec3<T> &lhs, const Vec3<T> &rhs)
00244 {
00245   Vec3<T> res{lhs};
00246   res -= rhs;
00247   return res;
00248 }
00249
00250 /**
00251  * @brief Overloaded multiple by value operator
00252  *
00253  * @tparam nT type of value to multiply by
00254  * @tparam T vector template parameter
00255  * @param[in] val value to multiply by
00256  * @param[in] rhs vector to multiply by value
00257  * @return Vec3<T> result vector
00258  */
00259 template <Number nT, std::floating_point T>
00260 Vec3<T> operator*(const nT &val, const Vec3<T> &rhs)
00261 {
00262   Vec3<T> res{rhs};
00263   res *= val;
00264   return res;
00265 }
00266
00267 /**
00268  * @brief Overloaded multiple by value operator
00269  *
00270  * @tparam nT type of value to multiply by
00271  * @tparam T vector template parameter
00272  * @param[in] val value to multiply by
00273  * @param[in] lhs vector to multiply by value
00274  * @return Vec3<T> result vector
00275  */
00276 template <Number nT, std::floating_point T>
00277 Vec3<T> operator*(const Vec3<T> &lhs, const nT &val)
```

```
00278 {
00279   Vec3<T> res{lhs};
00280   res *= val;
00281   return res;
00282 }
00283
00284 /**
00285  * @brief Overloaded divide by value operator
00286  *
00287  * @tparam nT type of value to divide by
00288  * @tparam T vector template parameter
00289  * @param[in] val value to divide by
00290  * @param[in] lhs vector to divide by value
00291  * @return Vec3<T> result vector
00292  */
00293 template <Number nT, std::floating_point T>
00294 Vec3<T> operator/(const Vec3<T> &lhs, const nT &val)
00295 {
00296   Vec3<T> res{lhs};
00297   res /= val;
00298   return res;
00299 }
00300
00301 /**
00302  * @brief Dot product function
00303  *
00304  * @tparam T vector template parameter
00305  * @param[in] lhs first vector
00306  * @param[in] rhs second vector
00307  * @return T dot production
00308  */
00309 template <std::floating_point T>
00310 T dot(const Vec3<T> &lhs, const Vec3<T> &rhs)
00311 {
00312   return lhs.dot(rhs);
00313 }
00314
00315 /**
00316  * @brief Cross product function
00317  *
00318  * @tparam T vector template parameter
00319  * @param[in] lhs first vector
00320  * @param[in] rhs second vector
00321  * @return T cross production
00322  */
00323 template <std::floating_point T>
00324 Vec3<T> cross(const Vec3<T> &lhs, const Vec3<T> &rhs)
00325 {
00326   return lhs.cross(rhs);
00327 }
00328
00329 /**
00330  * @brief Triple product function
00331  *
00332  * @tparam T vector template parameter
00333  * @param[in] v1 first vector
00334  * @param[in] v2 second vector
00335  * @param[in] v3 third vector
00336  * @return T triple production
00337  */
00338 template <std::floating_point T>
00339 T triple(const Vec3<T> &v1, const Vec3<T> &v2, const Vec3<T> &v3)
00340 {
00341   return dot(v1, cross(v2, v3));
00342 }
00343
00344 /**
00345  * @brief Vec3 print operator
00346  *
00347  * @tparam T vector template parameter
00348  * @param[in, out] ost output stream
00349  * @param[in] vec vector to print
00350  * @return std::ostream& modified stream instance
00351  */
00352 template <std::floating_point T>
00353 std::ostream &operator«(std::ostream &ost, const Vec3<T> &vec)
00354 {
00355   ost « "(" « vec.x « ", " « vec.y « ", " « vec.z « ")";
00356   return ost;
00357 }
00358
00359 /**
00360  * @brief Vec3 scan operator
00361  *
00362  * @tparam T vector template parameter
00363  * @param[in, out] ist input stram
00364  * @param[in, out] vec vector to scan
```

```
00365  * @return std::istream& modified stream instance
00366  */
00367 template <std::floating_point T>
00368 std::istream &operator»(std::istream &ist, Vec3<T> &vec)
00369 {
00370   ist » vec.x » vec.y » vec.z;
00371   return ist;
00372 }
00373
00374 using Vec3D = Vec3<double>;
00375 using Vec3F = Vec3<float>;
00376
00377 template <std::floating_point T>
00378 bool Vec3<T>::operator==(const Vec3 &rhs) const
00379 {
00380   return isEqual(rhs);
00381 }
00382
00383 template <std::floating_point T>
00384 bool Vec3<T>::operator!=(const Vec3 &rhs) const
00385 {
00386   return !operator==(rhs);
00387 }
00388
00389 template <std::floating_point T>
00390 Vec3<T> &Vec3<T>::operator+=(const Vec3 &vec)
00391 {
00392   x += vec.x;
00393   y += vec.y;
00394   z += vec.z;
00395
00396   return *this;
00397 }
00398
00399 template <std::floating_point T>
00400 Vec3<T> &Vec3<T>::operator-=(const Vec3 &vec)
00401 {
00402   x -= vec.x;
00403   y -= vec.y;
00404   z -= vec.z;
00405
00406   return *this;
00407 }
00408
00409 template <std::floating_point T>
00410 Vec3<T> Vec3<T>::operator-() const
00411 {
00412   return Vec3{-x, -y, -z};
00413 }
00414
00415 template <std::floating_point T>
00416 template <Number nType>
00417 Vec3<T> &Vec3<T>::operator*=(nType val)
00418 {
00419   auto fval = static_cast<T>(val);
00420   x *= fval;
00421   y *= fval;
00422   z *= fval;
00423
00424   return *this;
00425 }
00426
00427 template <std::floating_point T>
00428 template <Number nType>
00429 Vec3<T> &Vec3<T>::operator/=(nType val)
00430 {
00431   auto fval = static_cast<T>(val);
00432   x /= fval;
00433   y /= fval;
00434   z /= fval;
00435
00436   return *this;
00437 }
00438
00439 template <std::floating_point T>
00440 T Vec3<T>::dot(const Vec3 &rhs) const
00441 {
00442   return x * rhs.x + y * rhs.y + z * rhs.z;
00443 }
00444
00445 template <std::floating_point T>
00446 Vec3<T> Vec3<T>::cross(const Vec3 &rhs) const
00447 {
00448   return Vec3{y * rhs.z - z * rhs.y, z * rhs.x - x * rhs.z, x * rhs.y - y * rhs.x};
00449 }
00450
00451 template <std::floating_point T>
```

```
00452 T Vec3<T>::length2() const
00453 {
00454   return dot(*this);
00455 }
00456
00457 template <std::floating_point T>
00458 T Vec3<T>::length() const
00459 {
00460   return std::sqrt(length2());
00461 }
00462
00463 template <std::floating_point T>
00464 Vec3<T> Vec3<T>::normalized() const
00465 {
00466   Vec3 res{*this};
00467   res.normalize();
00468   return res;
00469 }
00470
00471 template <std::floating_point T>
00472 Vec3<T> &Vec3<T>::normalize() &
00473 {
00474   T len2 = length2();
00475   if (isZeroThreshold(len2) || isEqualThreshold(len2, T{1}))
00476     return *this;
00477   return *this /= std::sqrt(len2);
00478 }
00479
00480 template <std::floating_point T>
00481 T &Vec3<T>::operator[](std::size_t i) &
00482 {
00483   switch (i % 3)
00484   {
00485   case 0:
00486     return x;
00487   case 1:
00488     return y;
00489   case 2:
00490     return z;
00491   default:
00492     throw std::logic_error{"Impossible case in operator[]\n"};
00493   }
00494 }
00495
00496 template <std::floating_point T>
00497 T Vec3<T>::operator[](std::size_t i) const &
00498 {
00499   switch (i % 3)
00500   {
00501   case 0:
00502     return x;
00503   case 1:
00504     return y;
00505   case 2:
00506     return z;
00507   default:
00508     throw std::logic_error{"Impossible case in operator[]\n"};
00509   }
00510 }
00511
00512 template <std::floating_point T>
00513 T &&Vec3<T>::operator[](std::size_t i) &&
00514 {
00515   switch (i % 3)
00516   {
00517   case 0:
00518     return std::move(x);
00519   case 1:
00520     return std::move(y);
00521   case 2:
00522     return std::move(z);
00523   default:
00524     throw std::logic_error{"Impossible case in operator[]\n"};
00525   }
00526 }
00527
00528 template <std::floating_point T>
00529 bool Vec3<T>::isPar(const Vec3 &rhs) const
00530 {
00531   return cross(rhs).isEqual(Vec3<T>{0});
00532 }
00533
00534 template <std::floating_point T>
00535 bool Vec3<T>::isPerp(const Vec3 &rhs) const
00536 {
00537   return isZeroThreshold(dot(rhs));
00538 }
```

```
00539
00540 template <std::floating_point T>
00541 bool Vec3<T>::isEqual(const Vec3 &rhs) const
00542 {
00543   return isEqualThreshold(x, rhs.x) && isEqualThreshold(y, rhs.y) && isEqualThreshold(z, rhs.z);
00544 }
00545
00546 } // namespace geom
00547
00548 #endif // __INCLUDE_PRIMITIVES_VEC3_HH__
```