Template Metaprogramming and `<type_traits>`

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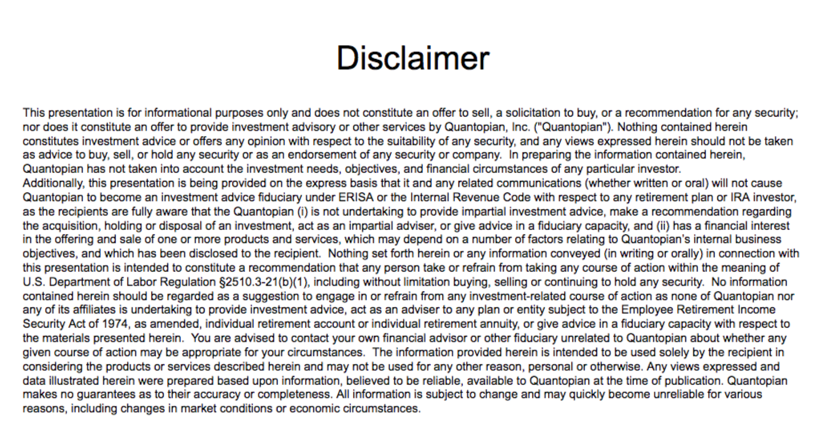
Boston C++



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Outline

1. Template types
2. Template functions
3. Advanced template concepts
4. Computation model of templates
5. Overview of `<type_traits>`
6. Selected examples

Template Types

Template Types

```
class vec2d_int {
private:
    const int m_x;
    const int m_y;

public:
    vec2d_int(int, int);
    int x() const;
    int y() const;
    int dot(const vec2d_int&) const;
};
```

Template Types

```
class vec2d_float {
private:
    const float m_x;
    const float m_y;

public:
    vec2d_float(float, float);
    float x() const;
    float y() const;
    float dot(const vec2d_float&) const;
};
```

Template Types

```
class vec2d_double {
private:
    const double m_x;
    const double m_y;

public:
    vec2d_double(double, double);
    double x() const;
    double y() const;
    double dot(const vec2d_double&) const;
};
```

Template Types

```
int vec2d_int::dot() {
    return m_x * other.m_x + m_y * other.m_y;
}
```

Template Types

```
int vec2d_int::dot() {
    return m_x * other.m_x + m_y * other.m_y;
}

float vec2d_float::dot() {
    return m_x * other.m_x + m_y * other.m_y;
}
```

Template Types

```
int vec2d_int::dot() {
    return m_x * other.m_x + m_y * other.m_y;
}

float vec2d_float::dot() {
    return m_x * other.m_x + m_y * other.m_y;
}

double vec2d_double::dot() {
    return m_x * other.m_x + m_y * other.m_y;
}
```

Template Types

```
template<typename T>
class vec2d {
private:
    const T m_x;
    const T m_y;

public:
    vec2d(const T&, const T&);
    const T& x() const;
    const T& y() const;
    T dot(const vec2d&) const;
};
```

Template Types

```cpp
template<typename T>
T vec2d<T>::dot(const vec2d<T>& other) const {
    return m_x * other.m_x + m_y * other.m_y;
}
```

Template Types

```
vec2d<int> int_vector(2, 4);
vec2d<float> float_vector(2.5, 4.5);
vec2d<double> double_vector(2.5, 4.5);
```

Template Types

```
struct not_a_numeric_type {};

vec2d<not_a_numeric_type> v(not_a_numeric_type{},
                            not_a_numeric_type{});
not_a_numeric_type dotted = v.dot(v);
```

Template Types

```
scratch.cc: In instantiation of
    T vec2d<T>::dot(const vec2d<T>&) const
    [with T = not_a_numeric_type]:
scratch.cc:31:40:   required from here
scratch.cc:21:20: error: no match for operator*
    (operand types are
     const not_a_numeric_type and
     const not_a_numeric_type)
         return m_x * other.m_x + m_y * other.m_y;
                ~~~~~~~~~~~~~~~
```

Template Types

```
class z5 {
private:
    std::uint8_t m_value;

public:
    z5(int);
    z5 operator+(const z5&) const;
    z5 operator*(const z5&) const;
};

vec2d<z5> v(1, 2);
z5 dotted = v.dot(v);
```

Value Parameters

```
template<typename T>
class vec3d {
private:
    const T m_x;
    const T m_y;
    const T m_z;

public:
    vec3d(const T&, const T&, const T&);
    const T& x() const;
    const T& y() const;
    const T& z() const;
    vec3d dot(const vec3d& other) const;
};
```

Value Parameters

```
template<typename T>
class vec4d {
private:
    const T m_axis_0;
    const T m_axis_1;
    const T m_axis_2;
    const T m_axis_3;

public:
    vec4d(const T&, const T&, const T&, const T&);
    const T& axis_0() const;
    // ...
    vec4d dot(const vec4d& other) const;
};
```

Value Parameters

```cpp
#include <array>

template<typename T, std::size_t size>
class vecnd {
private:
    std::array<T, size> m_data;

public:
    vecnd(const std::array<T, size>&>);
    const T& operator[](std::size_t) const;
    T dot(const vecnd&) const;
};
```

Value Parameters

```
template<typename T, std::size_t size>
T vecnd<T, size>::dot(const vecnd<T, size>& other) const {
    T sum = 0;
    for (std::size_t ix = 0; ix < size; ++ix) {
        sum += (*this)[ix] * other[ix];
    }
    return sum;
}
```

Value Parameters

```
vecnd<int, 4> v({1, 2, 3, 4});
```

Thank You

Questions?

JoeJev
Performance:5,757pp
Accuracy:98.38%
Lv100
#5892

`github.com/llllllllll` **(10 lowercase L’s)**

- `/lain` (model implementation)
- `/slider` (tools for working with osu! data and API)
- `/combine` (irc server running lain-as-a-service)