Rust/C++ Interop

Boulder Rust Meetup

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Tyler Weaver

- Regular C++ Programmer
- Rust Cult Member
- Open-source Robotcist
- Wrote a Rust Library with C++ Bindings

What Are We Going To Cover

- Social Objectsions to Rust
- Details of Interop
- Examples of Useful Patterns
- Code Generation Tools

A Collective Craft

Quality of your project has more to do with the people that build it than the tools selected. It is fine and good for the people to like their tools.

- C++ code that exists has value
- A little Rust is better than no Rust

Golden Gate Bridge

Before We Begin

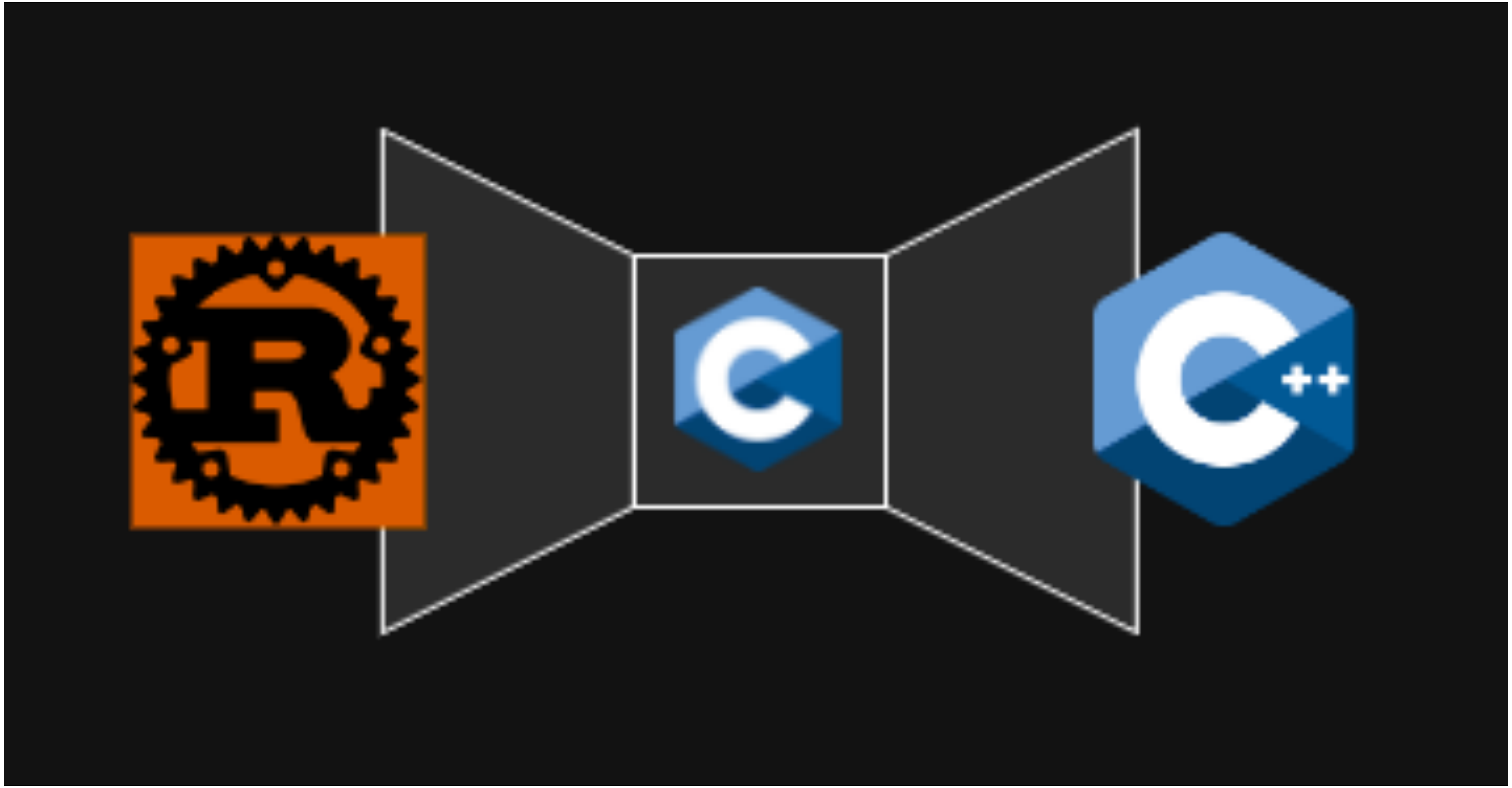
Code Generators

- cxx – Safe interop between Rust and C++
- bindgen – generate Rust FFI to C/C++ headers
- cbindgen – generate C headers for Rust FFI

Why Not

- Eigen C++ types <=> Nalgebra Rust types

Hourglass Language Bridge



Project Layout

```
├── Cargo.toml
├── crates
│   ├── robot_joint
│   │   ├── Cargo.toml
│   │   └── src
│   │       └── lib.rs
│   └── robot_joint-cpp
│       ├── Cargo.toml
│       ├── CMakeLists.txt
│       ├── cmake
│       │   └── robot_jointConfig.cmake.in
│       ├── include
│       │   └── robot_joint.hpp
│       └── src
│           ├── lib.cpp
│           └── lib.rs
└── README.md
```

Zakim Bridge

PICKNIK

robot_joint/src/lib.rs

```rust
pub struct Joint {
    name: String,
    parent_link_to_joint_origin: Isometry3<f64>,
}

impl Joint {
    pub fn new() -> Self;
}
```

robot_joint-cpp/src/lib.rs

```rust
use robot_joint::Joint;

#[no_mangle]
extern "C" fn robot_joint_new() -> *mut Joint {
    Box::into_raw(Box::new(Joint::new()))
}

#[no_mangle]
extern "C" fn robot_joint_free(joint: *mut Joint) {
    unsafe {
        drop(Box::from_raw(joint));
    }
}
```

robot_joint-cpp/include/robot_joint.hpp

```cpp
struct RustJoint;

class Joint {
  public:
    Joint();
    ~Joint();

    // Disable copy as we cannot safely copy opaque pointers to rust objects.
    Joint(Joint& other) = delete;
    Joint& operator=(Joint& other) = delete;

    // Explicit move.
    Joint(Joint&& other);
    Joint& operator=(Joint&& other);

  private:
    RustJoint* joint_ = nullptr;
};
```

robot_joint-cpp/src/lib.cpp

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```cpp
#include "robot_joint.hpp"

extern "C" {
extern RustJoint* robot_joint_new();
extern void robot_joint_free(RustJoint*);
}
```

robot_joint-cpp/src/lib.cpp

```cpp
Joint::Joint() : joint_(robot_joint_new()) {}

Joint::~Joint() {
  if (joint_ != nullptr) {
    robot_joint_free(joint_);
  }
}

Joint::Joint(Joint&& other) : joint_(other.joint_) {
  other.joint_ = nullptr;
}

Joint& Joint::operator=(Joint&& other) {
  joint_ = other.joint_;
  other.joint_ = nullptr;
  return *this;
}
```

Build System Integration

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See My Blog for a link to CMake example

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Fremont Bridge

First-class Types

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robot_joint/src/lib.rs

```
impl Joint {
    pub fn calculate_transform(&self, variables: &[f64]) -> Isometry3<f64>;
}
```

robot_joint-cpp/include/robot_joint.hpp

```
class Joint {
  public:
    Eigen::Isometry3d calculate_transform(const Eigen::VectorXd& variables);
};
```

robot_joint-cpp/src/lib.rs

```rust
#[repr(C)]
struct Mat4d {
    data: [c_double; 16],
}

#[no_mangle]
extern "C" fn robot_joint_calculate_transform(
    joint: *const Joint,
    variables: *const c_double,
    size: c_uint,
) -> Mat4d {
    unsafe {
        let joint = joint.as_ref().expect("Invalid pointer to Joint");
        let variables = std::slice::from_raw_parts(variables, size as usize);
        let transform = joint.calculate_transform(variables);
        Mat4d {
            data: transform.to_matrix().as_slice().try_into().unwrap(),
        }
    }
}
```

robot_joint-cpp/src/lib.cpp

```cpp
struct Mat4d {
  double data[16];
};

extern "C" {
extern struct Mat4d robot_joint_calculate_transform(
  const RustJoint*, const double*, unsigned int);
}

Eigen::Isometry3d Joint::calculate_transform(const Eigen::VectorXd& variables)
{
  const auto rust_isometry = robot_joint_calculate_transform(
    joint_, variables.data(), variables.size());
  Eigen::Isometry3d transform;
  transform.matrix() = Eigen::Map<Eigen::Matrix4d>(rust_isometry.data);
  return transform;
}
```

Red Cliff Bridge

So What?

Rust / C++ Interop is Straightforward
Don’t Listen to the Naysayers

Attribution

Kyle's OptIk

github.com/kylc/optik