ECE326

PROGRAMMING LANGUAGES

Lecture 14 : Control Flow in Rust

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Control Flow

- No parenthesis
  - Conditions in control flow does not need parenthesis
    - Unlike in C/C++
- Expressions
  - Almost everything in Rust is an expression
    - Including loops and blocks
  - Their return value is the last expression in each block
    - do not add a semicolon, which makes it a statement
  - All branches must return the same type
    - Otherwise the compiler complains

If/Else

```
let n = 5;
if n < 0 {
        print!("{} is negative", n);
} else if n > 0 {
        print!("{} is positive", n);
} else {
        print!("{} is zero", n);
}

let big_n = if n < 10 && n > -10 {
        println!(", and is a small number, increase ten-fold");
        10 * n // no semicolon here
} else {
        println!(", and is a big number, halve the number");
        n / 2
}; // semicolon here (let is a statement)

println!("{} -> {}", n, big_n);
```

← normal usage

use as an expression
↓

Loop

- An infinite loop
  - Requires break statement to exit

```
loop {
        count += 1;
        if count == 3 {
                println!("three");
                // Skip the rest of this iteration
                continue;
        }
        println!("{}", count);
        if count == 5 {
                println!("OK, that's enough");
                // Exit this loop
                break;
        }
}
```

Retry

- Example
  - Loop until “successful”
  - Loop can also be an expression

```
let mut counter = 0;

let result = loop {
      counter += 1;

      if counter == 10 {
            break counter * 2; // return value of loop
      }

      println!("I only exit on 10");
};
```

While Loop

- Loop while condition is true

```
let mut n = 1;

while n < 101 {
      if n % 15 == 0 {
            println!("fizzbuzz");
      } else if n % 3 == 0 {
            println!("fizz");
      } else if n % 5 == 0 {
            println!("buzz");
      } else {
            println!("{}", n);
      }

      n += 1;
}
```

For Loop

- Uses iterator to loop through elements of a collection
- Range
  - Similar to Python, creates an iterator for integers
  - a..b
    - Loops from a to b-1

```
for n in 1..101
```

  - a..=b
    - Loops from a to b

```
for n in 1..=100
```

Vector

- Similar to std::vector
  - Element type can be inferred by first element inserted
- vec!
  - Macro to initialize the vector

```
let mut v = vec![1, 2, 3]; // type of v is Vec<integer>
v.push(5);                 // add more elements to v
v.push(6);
```

- Vec::new()

```
let mut v = Vec::new();    // Empty new vector
v.push("hello");           // now a vector of &str
```

Loop Ownership

- Loop *can* be an owner
  - Must decide ownership of each element during loop

1. Read-only loop
   - Elements are borrowed from container
   - Container remains the same after loop

```
for i in &v {                    // read-only loop
      print!("{} ", i);
}

// output
1 2 3
```

Loop Ownership

- Loop *can* be an owner
  - Must decide ownership of each element during loop

2. Read-write loop
   - Elements are borrowed *mutably* from container
     - Each element can be updated during loop

```
for i in &mut v {           // read-update loop
        *i += 10;
}

// output is [11, 12, 13]
println!("{:?}", v)
```

Loop Ownership

- Loop *can* be an owner
  - Must decide ownership of each element during loop

3. Move loop
   - Elements are moved *out* of the container
     - And freed after each element goes out of scope
   - Container is inaccessible after loop

```
let mut n = 0;
for i in v {
    n += i;
}
// n is 6
```

Match

- The switch statement of Rust
  - But much more powerful and more frequently used
- Has ability to pattern match
  - Known as “destructuring”
- Can specify conditions
  - Similar to a set of if…else if statements
- Compiler requires all possible values to be handled
  - E.g. it is an error to miss one of the enum values

Match

- Syntax

```
match expression {
      pattern => expression, // this is called an “arm”
      pattern => expression,
       …
}
```

- Example

```
let boolean = true;
let binary = match boolean {
      false => 0,
      true => 1,
};
println!("{} -> {}", boolean, binary); // true -> 1
```

Match

- Match on an integer

```
let number = 13;

println!("Tell me about {}", number);
match number {
        // Match a single value
        1 => println!("One!"),
        // Match several values
        2 | 3 | 5 | 7 | 11 => println!("This is a prime"),
        // Match an inclusive range
        13...19 => println!("A teen"),
        // Handle the rest of cases
        _ => println!("Ain't special"),
}
```

... is inclusive, .. is exclusive (e.g. 13..19 matches 13 to 18)

_ is the catch-all case (same as default in C/C++)

Destructuring

- Allows matching of value(s) inside tuples

```
let pair = (0, -2);

match pair {
    (0, y) => println!("First is `0` and `y` is `{:?}`", y),
    (x, 0) => println!("`x` is `{:?}` and last is `0`", x),
         _ => println!("It doesn't matter what they are"),
}
```

- Guards (the if conditions)

```
match pair {
    (x, y) if x == y => println!("These are twins"),
    (x, y) if x + y == 0 => println!("Antimatter, kaboom!"),
    (x, _) if x % 2 == 1 => println!("The first one is odd"),
                      _ => println!("No correlation..."),
}
```

Enum in Rust

- Much more powerful than enums in C/C++
- Each value in enum must be scoped (using :: operator)
- Unlike C/C++, can *never* be assigned an integer value

```
enum Coin { Penny, Nickel, Dime, Quarter, }

fn value_in_cents(coin: Coin) -> u32 {
      match coin {
            Coin::Penny => 1,
            Coin::Nickel => 5,
            Coin::Dime => 10,
            Coin::Quarter => 25,
      } // no semicolon here so we return what match returns
}
```

Variant Type

- Also known as tagged union in C/C++
  - Algebraic data type in functional programming languages
- Data can be placed directly into each variant of enum
  - Each variant can have its own set of data

```
enum IpAddr {
      V4(u8, u8, u8, u8),
      V6(String),
}

let home = IpAddr::V4(127, 0, 0, 1);
let loopback = IpAddr::V6(String::from("::1"));
```

Destructuring

- Access data inside an enum variant

```
enum Color {
    RGB(u32, u32, u32),
    HSV(u32, u32, u32),
    CMYK(u32, u32, u32, u32),
}

match color {
    // binds name r, g, b to each piece of data inside variant RGB
    Color::RGB(r, g, b) =>
        println!("Red: {}, green: {}, and blue: {}!", r, g, b),
    Color::HSV(h, s, v) =>
        println!("Hue: {}, saturation: {}, value: {}!", h, s, v),
    Color::CMYK(c, m, y, k) =>
        println!("Cyan: {}, magenta: {}, yellow: {}, key (black): {}!",
            c, m, y, k),
}
```

Option<T>

- Commonly used enum
- Replaces use of null pointer
  - provides safety for values that can be null

```
enum Option<T> {  // already defined in standard library
      Some(T),    // as a generic type
      None,
}

// Returns Some(x) if a is divisible by b
fn int_div(a: i32, b: i32) -> Option<i32> {
    if a % b == 0 { Some(a/b) }
    else { None }
}
```

If let

- Useful for matching one specific enum
  - Looks much cleaner than match

```
// syntax 1: using match
match optional {
    Some(i) => {
        println!("This is a really long string and `{:?}`", i);
    },
    _ => {}, // required because match is exhaustive
};

// syntax 2: using if let
if let Some(i) = optional {
    println!("Matched {:?}!", i);
} else {
    // Destructure failed.
    println!("Was not a Some!");
}
```

Result<T, E>

- Commonly used for error handling

```
enum Result<T, E> {  // already defined in standard library
      Ok(T),         // as a generic type
      Err(E),
}

let f = File::open("hello.txt");
let f = match f {
      Ok(file) => file,
      Err(error) => {
            // this is how you write multiline string in Rust
            panic!("There was a problem opening the file: \
                  {:?}", error)
      },
};
```

Error Handling

- unwrap() / expect(msg)
  - Attempt to access data inside Ok, panic if Err is found

```
let f = File::open("hello.txt").unwrap();
let f = File::open("hello.txt").expect("Failed to open hello.txt");
```

- ? operator
  - Returns the same error inside Err() immediately
  - Requires return type of function to also be Result<T, E>

```
fn read_username_from_file() -> Result<String, io::Error> {
        let mut f = File::open("hello.txt")?;   // returns on error
        let mut s = String::new();
        f.read_to_string(&mut s)?;              // returns on error
        Ok(s)
}
```