

5h. In-Place Functions

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INTRODUCTION

This section continues exploring **approaches to mutating vectors**. The emphasis is now on **in-place functions**, defined as functions that mutate at least one of their arguments.

Many built-in functions in Julia have an in-place counterpart, which can easily be recognized by the `!` suffix in their names. These versions store the output in one of the function arguments, thereby avoiding the creation of a new object. In practice, it means that variables can be updated immediately after executing the function. For example, given a vector `x`, the call `sort(x)` produces a new vector with ordered elements, but without altering the original `x`. In contrast, the in-place version `sort!(x)` overwrites the content of `x`.

The benefits of in-place functions will become evident in Part II, when discussing high-performance computing. Essentially, by reusing existing objects, in-place functions eliminate the overhead associated with creating new objects.

IN-PLACE FUNCTIONS

In-place functions, also known as **mutating functions**, are characterized by their ability to modify at least one of their arguments. For example, given a vector `x`, the following function `foo(x)` constitutes an example of in-place function, as it modifies the content of `x`.

```
y = [0,0]
```

```
function foo(x)
    x[1] = 1
end
```

```
julia> y
```

```
2-element Vector{Int64}:
```

```
0
```

```
0
```

```
julia> foo(y) #it mutates 'y'
```

```
julia> y
```

```
2-element Vector{Int64}:
```

```
1
```

```
0
```

Functions Can't Reassign Variables

While functions are capable of mutating values, they **can't reassign variables defined outside their scope**. Any attempt to redefine such variable will be interpreted as the creation of a new local variable. ¹

The following code illustrates this behavior by redefining a function argument and a global variable. The output reflects that `foo` in each example treats the redefined `x` as a new local variable, only existing within `foo`'s scope.

```
x = 2

function foo(x)
    x = 3
end

julia> x
2
julia> foo(x)
julia> x #functions can't redefine global variables, only
mutate them
2
```

```
x = [1,2]

function foo()
    x = [0,0]
end

julia> x
2-element Vector{Int64}:
 1
 2
julia> foo()
julia> x #functions can't redefine variables globally, only
mutate them
2-element Vector{Int64}:
 1
 2
```

BUILT-IN IN-PLACE FUNCTIONS

In Julia, many built-in functions that take vectors as arguments are available in two forms: a "standard" version and an in-place version. To distinguish between them, Julia's developers follow a convention that **any function ending with `!` corresponds to an in-place function**.

Appending ! To A Function Has No Impact

Appending `!` to a function doesn't change the function's behavior.

It's simply a convention adopted by Julia's developers to emphasize the mutable nature of the operation. Its purpose is to alert users about the potential side effects of the function, thus preventing unintended modifications of objects.

To illustrate these forms, let's start considering single-argument functions. In particular, we'll focus on `sort`. This arranges the elements of a vector in ascending order, with the option `rev=true` implementing a descending order. In its standard form, `sort(x)` creates a new vector containing the sorted elements, leaving the original vector `x` unchanged. In contrast, the in-place version `sort!(x)` directly updates the original vector `x`, overwriting its values with the sorted result.

```
x = [2, 1, 3]
```

```
output = sort(x)
```

```
julia> x
```

```
3-element Vector{Int64}:
```

```
2
```

```
1
```

```
3
```

```
julia> output
```

```
3-element Vector{Int64}:
```

```
1
```

```
2
```

```
3
```

```
x = [2, 1, 3]
```

```
sort!(x)
```

```
julia> x
```

```
3-element Vector{Int64}:
```

```
1
```

```
2
```

```
3
```

Regarding multiple-argument functions, it's common to include an argument whose sole purpose is to store outputs. For instance, given a function `foo` and a vector `x`, the built-in function `map(foo, x)` has an in-place version `map!(foo, <output vector>, x)`.

```
x = [1, 2, 3]
```

```
output = map(a -> a^2, x)
```

```
julia> x
```

```
3-element Vector{Int64}:
```

```
1
2
3
```

```
julia> output
```

```
3-element Vector{Int64}:
```

```
1
4
9
```

```
x = [1, 2, 3]
```

```
output = similar(x)           # we initialize `output`
```

```
map!(a -> a^2, output, x)     # we update `output`
```

```
julia> x
```

```
3-element Vector{Int64}:
```

```
1
2
3
```

```
julia> output
```

```
3-element Vector{Int64}:
```

```
1
4
9
```

FOR-LOOP MUTATION VIA IN-PLACE FUNCTION

In Julia, for-loops should always be wrapped in functions. This not only prevents issues with variable scope, but is also key for performance, as we'll discuss in Part II.

Considering this, the ability of functions to mutate their arguments is crucial. It determines that we can initialize vectors with `undef` values, pass them to a function, and fill them through a function via a for-loop. The examples below illustrate this application.

```
x = [3,4,5]

function foo!(x)
    for i in 1:2
        x[i] = 0
    end
end
```

```
julia> foo!(x)
julia> x
3-element Vector{Int64}:
 0
 0
 5
```

```
x = Vector{Int64}(undef, 3)           # initialize a vector with 3 elements

function foo!(x)
    for i in eachindex(x)
        x[i] = 0
    end
end
```

```
julia> foo!(x)
julia> x
3-element Vector{Int64}:
 0
 0
 0
```

FOOTNOTES

¹ Strictly speaking, it's possible to reassign a variable by using the `global` keyword. However, its use is typically discouraged, explaining why we won't cover it.