Understanding Your Struct Toolbox

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https://github.com/sbuercklin/StructToolbox

Structs aren’t just “Fancy NamedTuples”

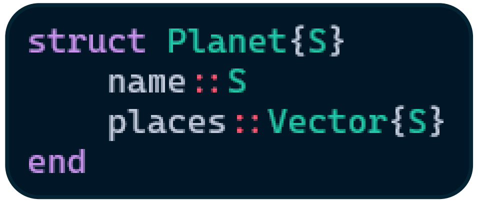
- Easy to think of structs as just objects for grouping fieldnames

- Much more fundamental
  - Dispatchable construct
  - Mutable (sometimes)
  - Often user-facing

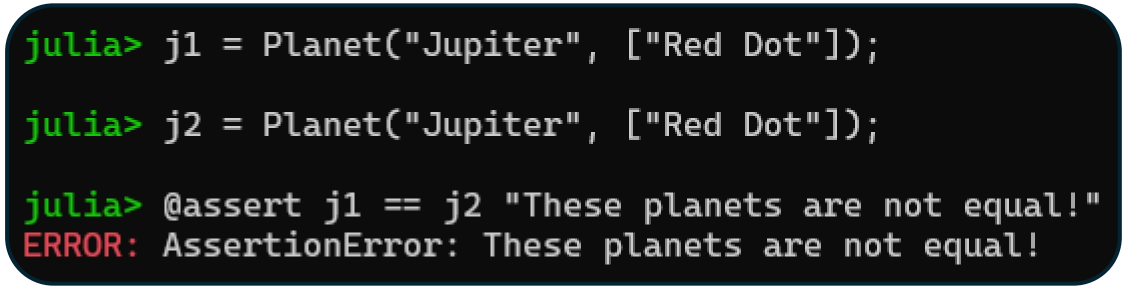
- Lots of Julia assumes you’re defining custom structs

Struct Equality

Equality



```julia
struct Planet{S}
    name::S
    places::Vector{S}
end
```

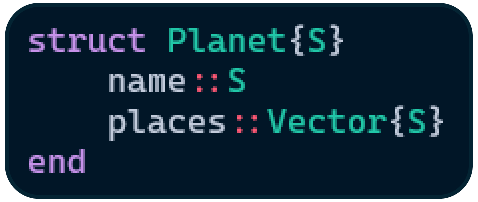


```
julia> j1 = Planet("Jupiter", ["Red Dot"]);

julia> j2 = Planet("Jupiter", ["Red Dot"]);

julia> @assert j1 == j2 "These planets are not equal!"
ERROR: AssertionError: These planets are not equal!
```

Equality



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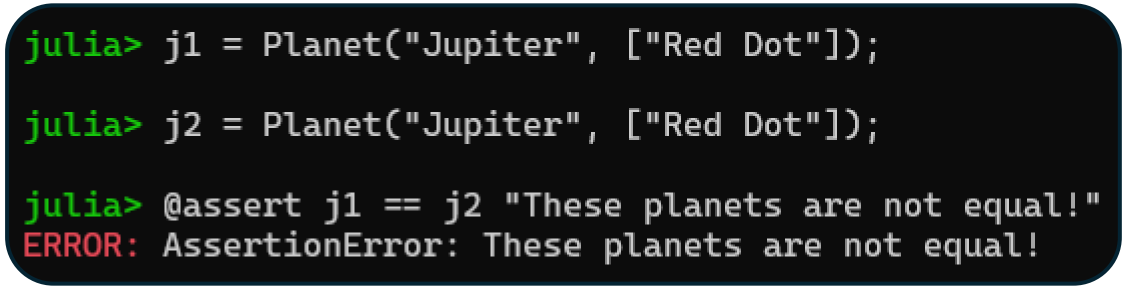

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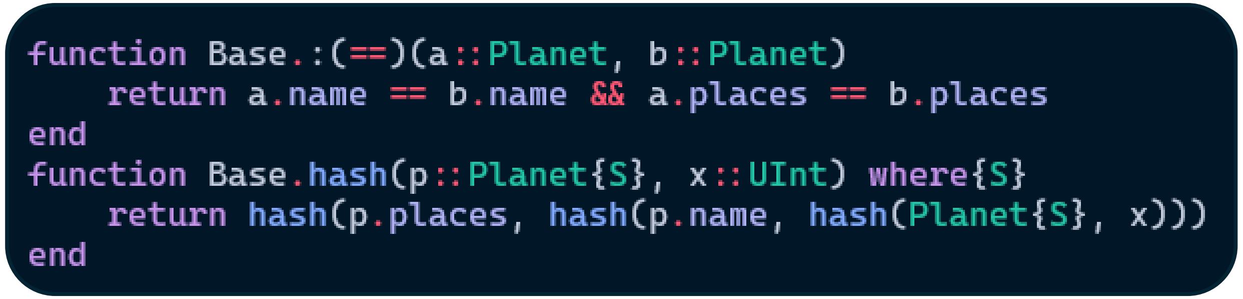
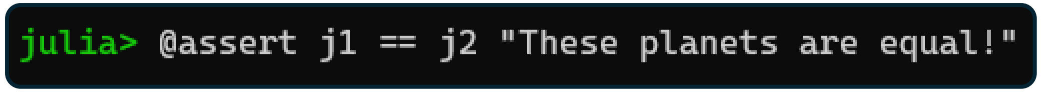


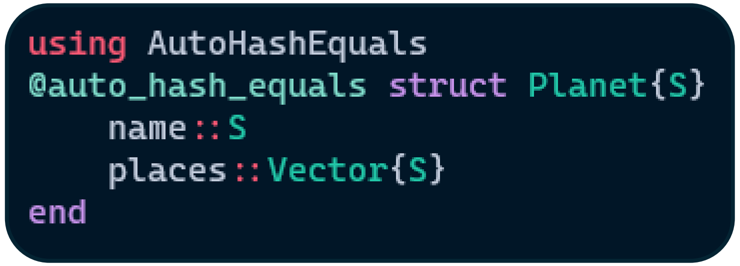
```julia
function Base.:(==)(a::Planet, b::Planet)
    return a.name == b.name && a.places == b.places
end
function Base.hash(p::Planet{S}, x::UInt) where{S}
    return hash(p.places, hash(p.name, hash(Planet{S}, x)))
end
```



```
julia> @assert j1 == j2 "These planets are equal!"
```

The Easy Way

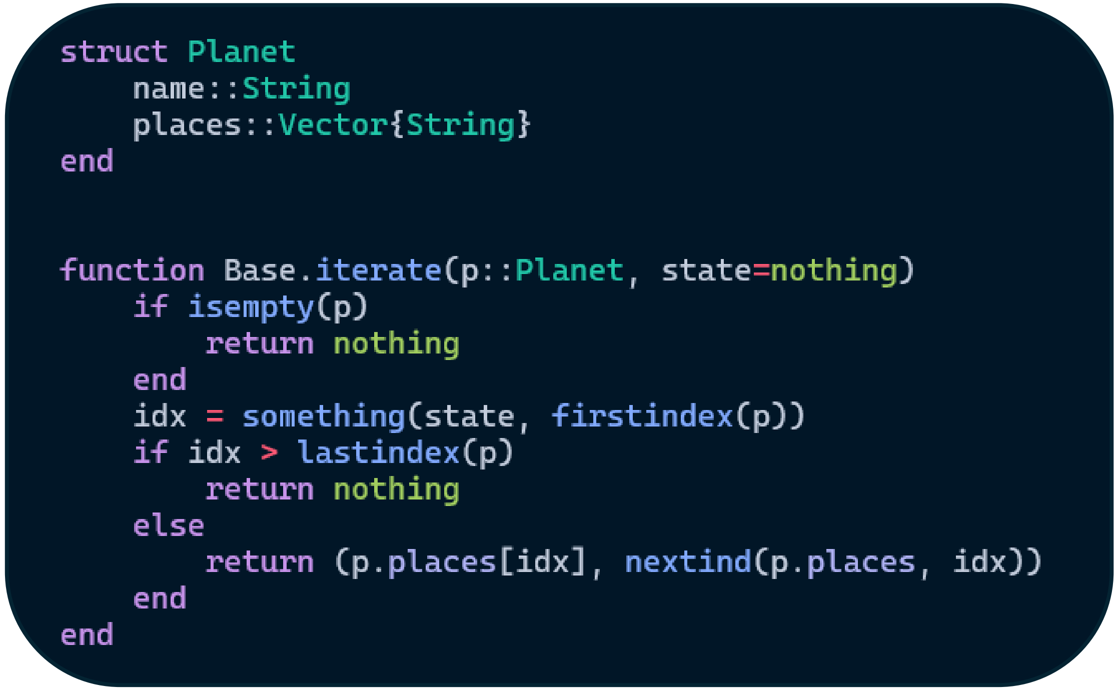
- Doing this from scratch is tedious and error-prone
  - AutoHashEquals.jl will do this automagically
  - Gotcha: hash the type in addition to field values



```julia
using AutoHashEquals
@auto_hash_equals struct Planet{S}
    name::S
    places::Vector{S}
end
```

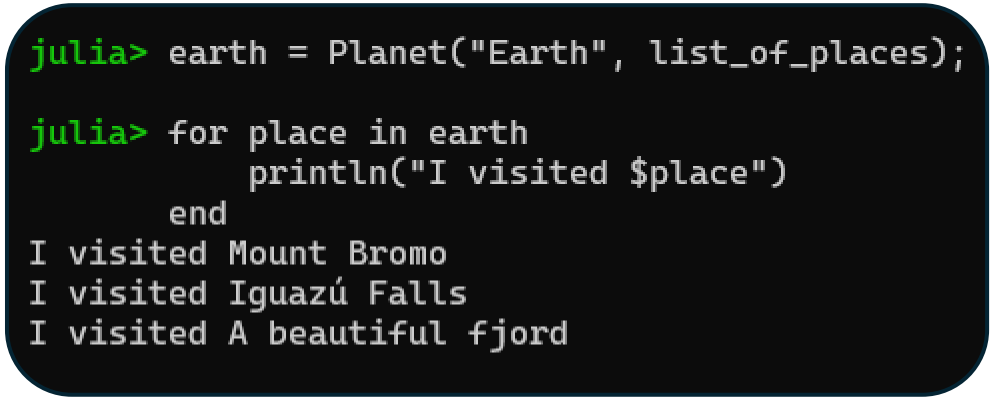
Struct Iteration

Iteration



```julia
struct Planet
    name::String
    places::Vector{String}
end


function Base.iterate(p::Planet, state=nothing)
    if isempty(p)
        return nothing
    end
    idx = something(state, firstindex(p))
    if idx > lastindex(p)
        return nothing
    else
        return (p.places[idx], nextind(p.places, idx))
    end
end
```



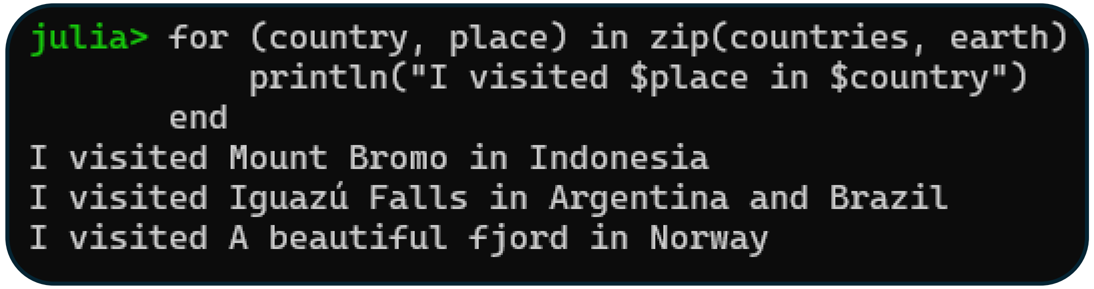
```
julia> earth = Planet("Earth", list_of_places);

julia> for place in earth
           println("I visited $place")
       end
I visited Mount Bromo
I visited Iguazú Falls
I visited A beautiful fjord
```

Iteration as an Interface

- Gives us better abstraction of types with contents
  - Iterate over a system as particles, or a mesh as cells, or…
  - Stop leaky abstractions!

- Unlocks higher order behaviors using iteration as an *interface*
  - *Building Confidently in Julia with Interface Driven Design*
  - https://youtu.be/mMO9NzkTxL0

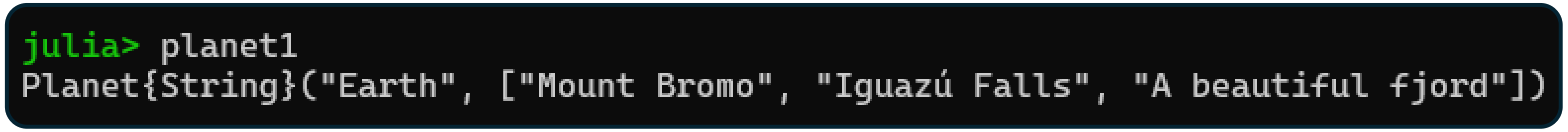


```
julia> for (country, place) in zip(countries, earth)
           println("I visited $place in $country")
       end
I visited Mount Bromo in Indonesia
I visited Iguazú Falls in Argentina and Brazil
I visited A beautiful fjord in Norway
```

Pretty Printing

Pretty-Printing

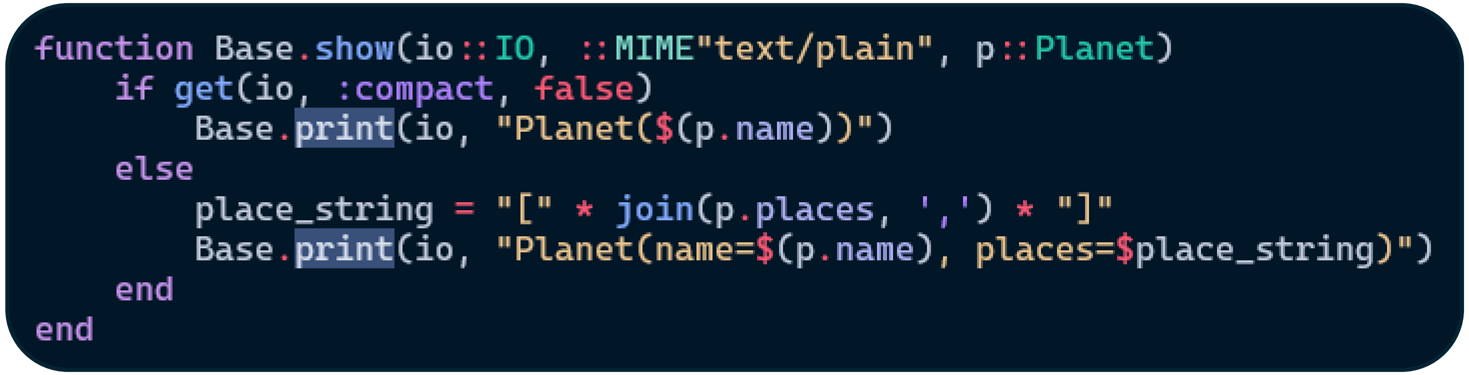
The default, 2-arg Base.show(io, x) method prints a representation which can be parsed



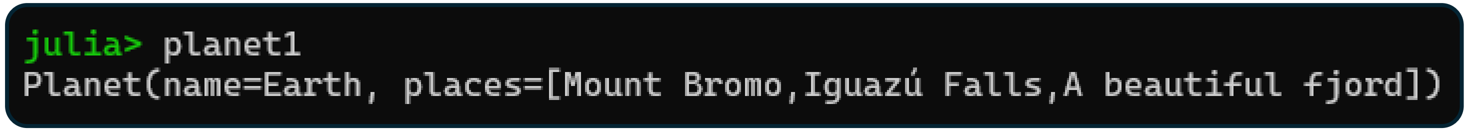
```
julia> planet1
Planet{String}("Earth", ["Mount Bromo", "Iguazú Falls", "A beautiful fjord"])
```

This is useful for copying small structs around, but we often
want a more interactive workflow

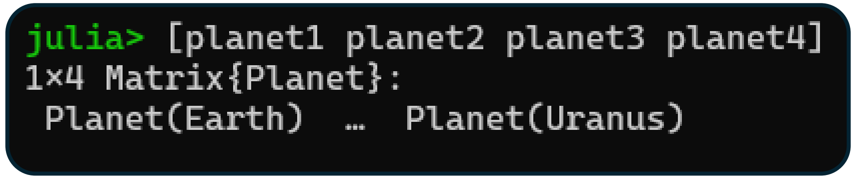
Pretty-Printing



```julia
function Base.show(io::IO, ::MIME"text/plain", p::Planet)
    if get(io, :compact, false)
        Base.print(io, "Planet($(p.name))")
    else
        place_string = "[" * join(p.places, ',') * "]"
        Base.print(io, "Planet(name=$(p.name), places=$place_string)")
    end
end
```

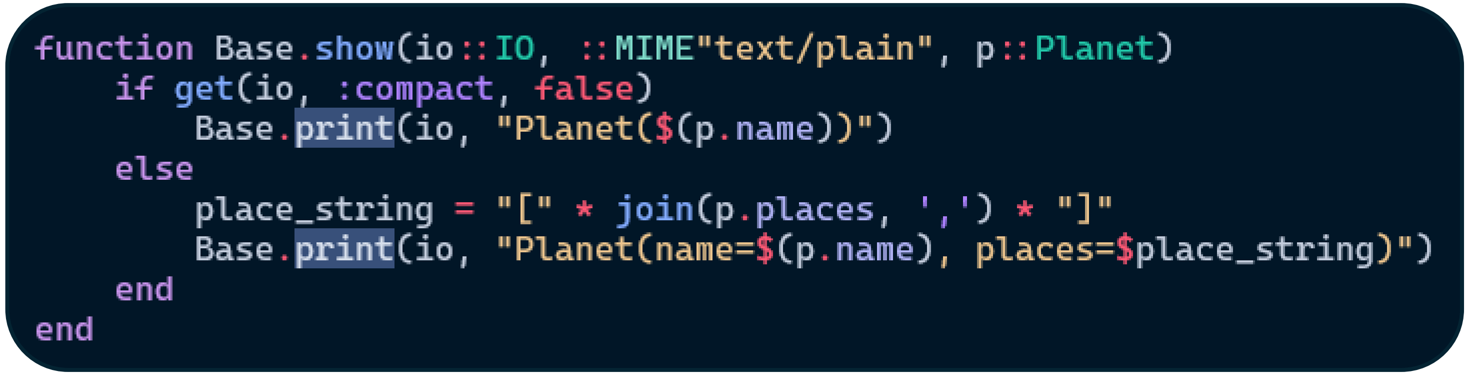


```
julia> planet1
Planet(name=Earth, places=[Mount Bromo,Iguazú Falls,A beautiful fjord])
```



```
julia> [planet1 planet2 planet3 planet4]
1×4 Matrix{Planet}:
 Planet(Earth)  …  Planet(Uranus)
```

Pretty-Printing



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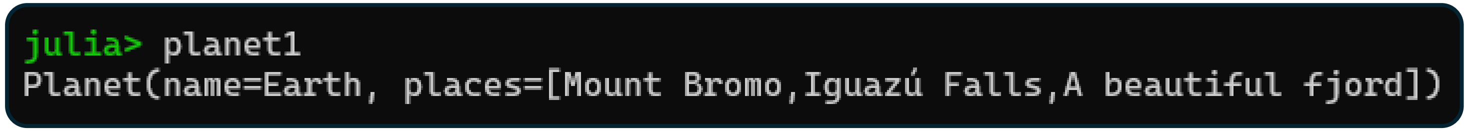
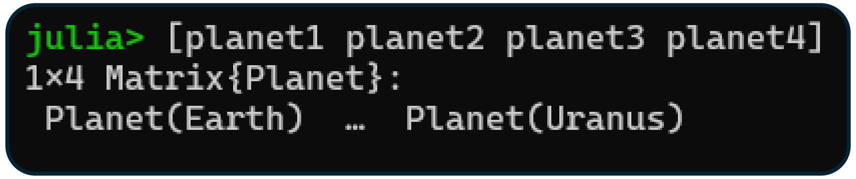
    else
        place_string = "[" * join(p.places, ',') * "]"
        Base.print(io, "Planet(name=$(p.name), places=$place_string)")
    end
end
```



```
julia> planet1
Planet(name=Earth, places=[Mount Bromo,Iguazú Falls,A beautiful fjord])
```



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julia> [planet1 planet2 planet3 planet4]
1×4 Matrix{Planet}:
 Planet(Earth)  …  Planet(Uranus)
```
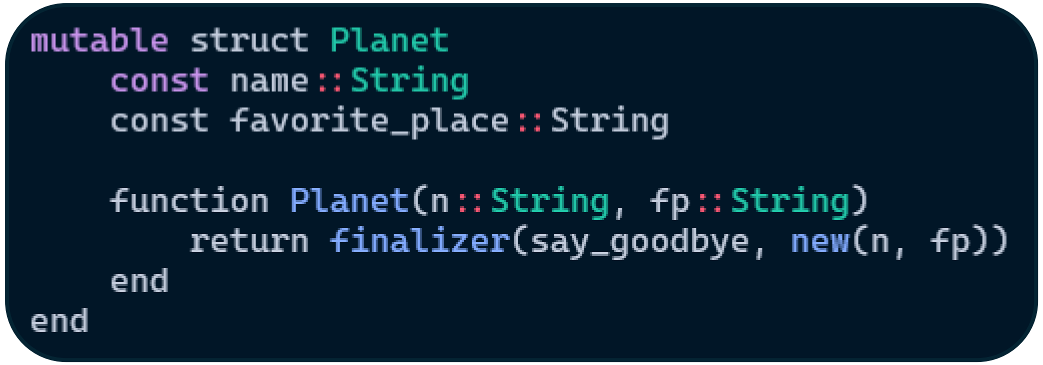
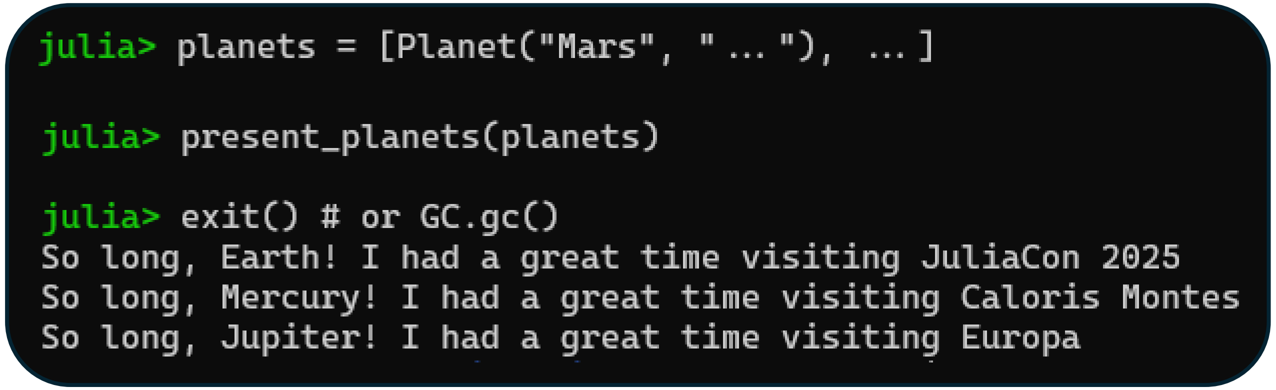

- Useful for interactive development
  - Summary statistics
  - Common names
  - Hide implementation details

Mutability and Identity

Mutable is more than Mutation (Finalizers)



```julia
mutable struct Planet
    const name::String
    const favorite_place::String

    function Planet(n::String, fp::String)
        return finalizer(say_goodbye, new(n, fp))
    end
end
```



```
julia> planets = [Planet("Mars", " ... "), ... ]

julia> present_planets(planets)

julia> exit() # or GC.gc()
So long, Earth! I had a great time visiting JuliaCon 2025
So long, Mercury! I had a great time visiting Caloris Montes
So long, Jupiter! I had a great time visiting Europa
```

Mutation is about identity

- Instances of mutable structs are distinguishable
  - Identity/distinguishability gives mutation, not the other way
  - === vs == (egal vs equal)

- Finalizers give us a way to exploit identity with Julia’s GC

- Most useful for things like C-FFI
  - Managing memory in other languages, packages
  - Underpins wrappers of external packages

Thank You!