```
Last login: Thu Jul 29 13:02:19 on ttys000
Chioma_N@Akwarandus-MacBook-Air ~ % exec '/Applications/Julia-1.6.app/Contents/R
esources/julia/bin/julia'
               _
   _       _ _(_)_     |  Documentation: https://docs.julialang.org
  (_)     | (_) (_)    |
   _ _   _| |_  __ _   |  Type "?" for help, "]?" for Pkg help.
  | | | | | | |/ _` |  |
  | | |_| | | | (_| |  |  Version 1.6.1 (2021-04-23)
 _/ |\__'_|_|_|\__'_|  |  Official https://julialang.org/ release
|__/                   |

julia> using NeuralVerification, LazySets, LinearAlgebra


julia> import NeuralVerification: ReLU, Id

julia> A = [[-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,
0,0,0,0,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,-1,0,0,0,0,0,0,0,0] [1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
[0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0] [0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0] [0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0] [0,0,0,1,-1,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0
,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0] [0,0,0,0,1,-1
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,
0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0] [0
,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,
0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1
,-1,0,0] [0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,1,-1,0] [0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0] [0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,-1,0,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,1,-1] [0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0] [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0] [0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1]]
27×30 Matrix{Int64}:
 -1   0   0   1  0   0   0  0   0   0  …  0   0  0   0   0  0   0  0  0  0
  0   0   0  -1  0   0   1  0   0   0     0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0  -1  0   0   1     0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0  -1     0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0     0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0  …  0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0     0   1  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0     0  -1  0   0   1  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0     0   0  0   0  -1  0   0  1  0  0
  0  -1   0   0  1   0   0  0   0   0     0   0  0   0   0  0   0  0  0  0
  ⋮                  ⋮                 ⋱  ⋮                 ⋮
  0   0  -1   0  0   1   0  0   0   0     0   0  0   0   0  0   0  0  0  0
```

```
  0   0   0   0  0  -1   0  0   1   0       0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0  -1   0  …    0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0       0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0       0   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0       1   0  0   0   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0      -1   0  0   1   0  0   0  0  0  0
  0   0   0   0  0   0   0  0   0   0  …    0   0  0  -1   0  0   1  0  0  0
  0   0   0   0  0   0   0  0   0   0       0   0  0   0   0  0  -1  0  0  1

julia> A = vcat(A, I(30), -I(30))
87×30 SparseArrays.SparseMatrixCSC{Int64, Int64} with 114 stored entries:
⋅  ⋮  ⋮  ⋱
      ⋱  ⋮  ⋮  ⋱  ⋮  ⋱
⋅  ⋮  ⋮  ⋱
      ⋱  ⋮  ⋮  ⋱  ⋮  ⋱
 ⋱  ⋮  ⋮  ⋱
      ⋱  ⋮  ⋮  ⋱  ⋮  ⋱
⋱
  ⋱  ⋮  ⋱
     ⋱  ⋱  ⋱
        ⋱  ⋱  ⋱
           ⋱  ⋱  ⋱
              ⋱  ⋱  ⋱
⋱
  ⋮  ⋱
     ⋱  ⋱  ⋱
        ⋱  ⋱  ⋱
           ⋱  ⋱  ⋱
              ⋱  ⋱  ⋱
                 ⋱  ⋱

julia> A = float(A)
87×30 SparseArrays.SparseMatrixCSC{Float64, Int64} with 114 stored entries:
⋅  ⋮  ⋮  ⋱
      ⋱  ⋮  ⋮  ⋱  ⋮  ⋱
⋅  ⋮  ⋮  ⋱
      ⋱  ⋮  ⋮  ⋱  ⋮  ⋱
 ⋱  ⋮  ⋮  ⋱
      ⋱  ⋮  ⋮  ⋱  ⋮  ⋱
⋱
  ⋱  ⋮  ⋱
     ⋱  ⋱  ⋱
        ⋱  ⋱  ⋱
           ⋱  ⋱  ⋱
              ⋱  ⋱  ⋱
⋱
  ⋮  ⋱
     ⋱  ⋱  ⋱
        ⋱  ⋱  ⋱
           ⋱  ⋱  ⋱
              ⋱  ⋱  ⋱
                 ⋱  ⋱
```

```
          ⋱
            ⋱
```

```
julia> b = [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]
27-element Vector{Int64}:
 0
 0
 0
 0
 0
 0
 0
 0
 0
 0
 ⋮
 0
 0
 0
 0
 0
 0
 0
 0
 0
```

```
julia> b = vcat(b, ones(60))
87-element Vector{Float64}:
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 ⋮
 1.0
 1.0
 1.0
 1.0
 1.0
 1.0
 1.0
 1.0
 1.0
```

```
julia> x = HPolytope(A, b)

HPolytope{Float64, SparseArrays.SparseVector{Float64, Int64}}(HalfSpace{Float64,
```

```
 SparseArrays.SparseVector{Float64, Int64}}[HalfSpace{Float64, SparseArrays.Spar
seVector{Float64, Int64}}(  [1 ]  =  -1.0
  [4 ]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [4 ]  =  -1.0
  [7 ]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [7 ]  =  -1.0
  [10]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [10]  =  -1.0
  [13]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [13]  =  -1.0
  [16]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [16]  =  -1.0
  [19]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [19]  =  -1.0
  [22]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [22]  =  -1.0
  [25]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [25]  =  -1.0
  [28]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [2 ]  =  -1.0
  [5 ]  =  1.0, 0.0)  …  HalfSpace{Float64, SparseArrays.SparseVector{Float64, I
nt64}}(  [21]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.SparseVector{Float
64, Int64}}(  [22]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.SparseVector{
Float64, Int64}}(  [23]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.SparseVe
ctor{Float64, Int64}}(  [24]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.Spa
rseVector{Float64, Int64}}(  [25]  =  -1.0, 1.0), HalfSpace{Float64, SparseArray
s.SparseVector{Float64, Int64}}(  [26]  =  -1.0, 1.0), HalfSpace{Float64, Sparse
Arrays.SparseVector{Float64, Int64}}(  [27]  =  -1.0, 1.0), HalfSpace{Float64, S
parseArrays.SparseVector{Float64, Int64}}(  [28]  =  -1.0, 1.0), HalfSpace{Float
64, SparseArrays.SparseVector{Float64, Int64}}(  [29]  =  -1.0, 1.0), HalfSpace{
Float64, SparseArrays.SparseVector{Float64, Int64}}(  [30]  =  -1.0, 1.0)])

julia> Ay = [1.0]
1-element Vector{Float64}:
 1.0

julia> by = 0.0
0.0

julia> y = HalfSpace(Ay, by)
HalfSpace{Float64, Vector{Float64}}([1.0], 0.0)

julia> model = "/Users/Chioma_N/Desktop/object/PCC-RL-master/src/gym/tensorflow/
reLuNet/resNet"
"/Users/Chioma_N/Desktop/object/PCC-RL-master/src/gym/tensorflow/reLuNet/resNet"

julia> net = read_nnet(model)
Network(NeuralVerification.Layer[NeuralVerification.Layer{ReLU, Float64}([-0.476
940215 -0.233635619 … 0.260245979 0.0854543895; -0.279218972 0.212435156 … -0.30
4853797 -0.287973344; … ; 0.043456167 -0.299254805 … -0.336141109 0.0869233087;
0.0609097183 -0.0746256411 … -0.356662869 -0.211450607], [-0.03726024, 0.0, 0.0,
 0.06048633, -0.11259795, 0.0, 0.0, -0.07211282, 0.044972, 0.0, 0.0, 0.0, 0.0, 0
```

```
.01267096, -0.00579271, 0.0], ReLU()), NeuralVerification.Layer{ReLU, Float64}([
-0.02278417 -0.15391123 … -0.40684664 -0.21582426; 0.27223375 0.23778197 … 0.137
33128 0.12970361; … ; 0.18829295 0.33743098 … 0.06836078 0.16406111; 0.37219688
-0.16067436 … -0.24720219 0.12515154], [0.0, 0.0, 0.06707639, 0.0, -0.07552656,
0.00930779, -0.00740244, 0.0, -0.04904214, 0.0, -0.02598077, 0.03745193, 0.03417
419, -0.01520709, 0.0, 0.01063646], ReLU()), NeuralVerification.Layer{Id, Float6
4}([0.30263627 -0.23838618 … -0.09799442 -0.00773645], [0.04735997], Id())])

julia> prob = Problem(net, x, y)
Problem{HPolytope{Float64, SparseArrays.SparseVector{Float64, Int64}}, HalfSpace
{Float64, Vector{Float64}}}(Network(NeuralVerification.Layer[NeuralVerification.
Layer{ReLU, Float64}([-0.476940215 -0.233635619 … 0.260245979 0.0854543895; -0.2
79218972 0.212435156 … -0.304853797 -0.287973344; … ; 0.043456167 -0.299254805 …
 -0.336141109 0.0869233087; 0.0609097183 -0.0746256411 … -0.356662869 -0.2114506
07], [-0.03726024, 0.0, 0.0, 0.06048633, -0.11259795, 0.0, 0.0, -0.07211282, 0.0
44972, 0.0, 0.0, 0.0, 0.0, 0.01267096, -0.00579271, 0.0], ReLU()), NeuralVerific
ation.Layer{ReLU, Float64}([-0.02278417 -0.15391123 … -0.40684664 -0.21582426; 0
.27223375 0.23778197 … 0.13733128 0.12970361; … ; 0.18829295 0.33743098 … 0.0683
6078 0.16406111; 0.37219688 -0.16067436 … -0.24720219 0.12515154], [0.0, 0.0, 0.
06707639, 0.0, -0.07552656, 0.00930779, -0.00740244, 0.0, -0.04904214, 0.0, -0.0
2598077, 0.03745193, 0.03417419, -0.01520709, 0.0, 0.01063646], ReLU()), NeuralV
erification.Layer{Id, Float64}([0.30263627 -0.23838618 … -0.09799442 -0.00773645
], [0.04735997], Id())]), HPolytope{Float64, SparseArrays.SparseVector{Float64,
Int64}}(HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int64}}[HalfSpace{
Float64, SparseArrays.SparseVector{Float64, Int64}}(  [1 ]  =  -1.0
  [4 ]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [4 ]  =  -1.0
  [7 ]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [7 ]  =  -1.0
  [10]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [10]  =  -1.0
  [13]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [13]  =  -1.0
  [16]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [16]  =  -1.0
  [19]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [19]  =  -1.0
  [22]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [22]  =  -1.0
  [25]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [25]  =  -1.0
  [28]  =  1.0, 0.0), HalfSpace{Float64, SparseArrays.SparseVector{Float64, Int6
4}}(  [2 ]  =  -1.0
  [5 ]  =  1.0, 0.0)  …  HalfSpace{Float64, SparseArrays.SparseVector{Float64, I
nt64}}(  [21]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.SparseVector{Float
64, Int64}}(  [22]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.SparseVector{
Float64, Int64}}(  [23]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.SparseVe
ctor{Float64, Int64}}(  [24]  =  -1.0, 1.0), HalfSpace{Float64, SparseArrays.Spa
rseVector{Float64, Int64}}(  [25]  =  -1.0, 1.0), HalfSpace{Float64, SparseArray
s.SparseVector{Float64, Int64}}(  [26]  =  -1.0, 1.0), HalfSpace{Float64, Sparse
Arrays.SparseVector{Float64, Int64}}(  [27]  =  -1.0, 1.0), HalfSpace{Float64, S
parseArrays.SparseVector{Float64, Int64}}(  [28]  =  -1.0, 1.0), HalfSpace{Float
```

```
64, SparseArrays.SparseVector{Float64, Int64}}(  [29]  =  -1.0, 1.0), HalfSpace{
Float64, SparseArrays.SparseVector{Float64, Int64}}(  [30]  =  -1.0, 1.0)]), Hal
fSpace{Float64, Vector{Float64}}([1.0], 0.0))

julia> res = solve(Neurify(max_iter=100), prob)
CounterExampleResult(:violated, [1.0, 1.0, 1.0, 1.0, -1.0, 1.0, -1.0, -1.0, 1.0,
 -1.0  …  1.0, -1.0, -1.0, 1.0, -1.0, -1.0, 1.0, -1.0, -1.0, 1.0])

julia>
```