Christmas_Island_complicated_implication_networks

21 June 2019

Boolean analysis for the combined cat and rat management for the full Town Network.

Read in the csv file of observed species-response combinations that we saved in advance for the full run of the parameter-sweep (number of matrices produced: 10^8).

```
observedResponse_df <- read.csv("town_search_full_10e8.csv", head = TRUE)
nrow(observedResponse_df)
```

```
## [1] 8930
```

1. Perform Boolean minimisation and get the PCUList

Performing the Boolean minimization on species responses to the combined management. Write a list of desired responses for this management.

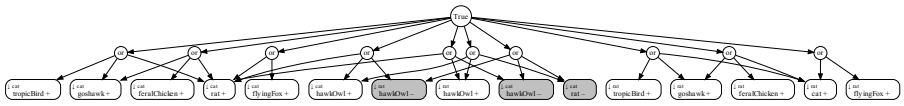
```
allResponse <- colnames(observedResponse_df)
# allResponse # check species response

str4true = 'pos'
str4flase = 'neg'

desiredResponses_cr = c(
  'cat_tropicBird',
  'cat_goshawk',
  'cat_feralChicken',
  'cat_hawkOwl',
  'cat_rat',
  'cat_flyingFox',
  'rat_tropicBird',
  'rat_goshawk',
  'rat_feralChicken',
  'rat_hawkOwl',
  'rat_cat',
  'rat_flyingFox')

boolLen_cr <- length(desiredResponses_cr)
desiredResponsesMask_cr <- match(desiredResponses_cr, allResponse)

unobservedInts_cr <- getUnobservedInts2(observedResponse_df, desiredResponsesMask_cr, boolLen_cr)

unobservedBooldf_cr <- getUnobservedBooldf(unobservedInts_cr, desiredResponses_cr)

opt_cr <- logicopt(unobservedBooldf_cr, boolLen_cr, 1, mode="espresso")
optEqn_cr <- tt2eqn(opt_cr[[1]], boolLen_cr, 1)

PCUList_cr <- getPCUList(optEqn_cr, str4true, str4flase, desiredResponses_cr)
```

Since the PCUList is quite large and complicated, we split the PCUList up by length.

```
PCUlength_cr <- sapply(PCUList_cr, function(i) length(i))
PCUList_cr1 <- PCUList_cr[PCUlength_cr <= 5]
PCUList_cr2 <- PCUList_cr[PCUlength_cr > 5]
```

Draw an implication network for all rules with length less than 5.

```
edgelist_cr1 <- get_edgelist_certainAnte(PCUList_cr1, c())
draw_implication_network(edgelist_cr1)
```



Above implication network shows that 'poscat_rat' 'negcat_rat' and 'posrat_cat' are central contingencies. Thus we analyze the implication rules under different scenarios based on the rat response to cat management and cat response to rat management.

2. Implication netwoks under different scenarios

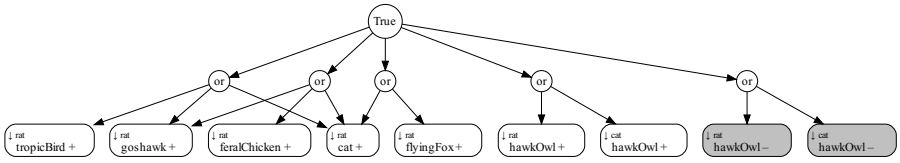
First, we split up the PCUs by the effects (positive/negtaive) of cat management on rat population. The always true conditions (here are "when cat management has a positive effect on rat population" and "when cat management has a negative effect on rat population" for PCULList_cr3 and PCUList_cr4 respectively) will be shown as "True" for a succinct presentation. There are rules only involving species-responses to cat management, which have been predicated by the cat only management scenario (see the document *Christmas_Island_Boolean_approach*). Thus, we can perform a further pruning, and these rules are predicated on "True".

```
PCUList_cr3 = list()
PCUList_cr4 = list()

for (PCU in PCUList_cr1){
    if (!('negcat_rat' %in% PCU)){
        if(!all(str_detect(PCU, "cat"))) {

            PCU <- str_subset(PCU, 'cat_rat', negate = TRUE)
```

```
            PCUList_cr3[[length(PCUList_cr3)+1]] <- PCU
        }
    }
}

for (PCU in PCUList_cr1){
    if (!('poscat_rat' %in% PCU)){
        if(!all(str_detect(PCU, "cat_"))) {

            PCU <- str_subset(PCU, 'cat_rat', negate = TRUE)
            PCUList_cr4[[length(PCUList_cr4)+1]] <- PCU
        }
    }
}
```

Scenario 1: when cat management has a positive effect on rat population.

```
edgelist_cr3 <- get_edgelist_certainAnte(PCUList_cr3, c())
draw_implication_network(edgelist_cr3)
```



From above implication network, we could further explore the implication rules under two scenarios given the effect of rat managemnet on cat population.

Scenario 1a: when cat management has a positive effect on rat population and rat management has a negative effect on cat population (this is the most likely scenario).

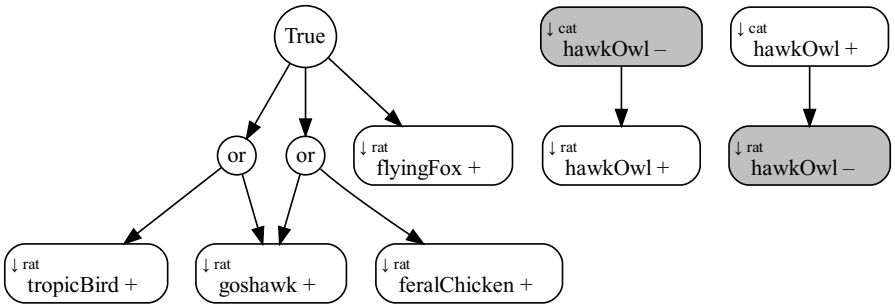
```
PCUList_cr5 = list()

for (PCU in PCUList_cr3){
    if (!('posrat_cat' %in% PCU)){
```

```
        PCU <- str_subset(PCU, 'rat_cat', negate = TRUE)
        PCUList_cr5[[length(PCUList_cr5)+1]] <- PCU
    }
}
```

The always true conditions (here are "when cat management has a positive effect on rat population and rat management has a negative effect on cat population") are shown as "True" for a succinct presentation.

In addtion, there is a better way to present the network given that the effect of rat management upon the hawk-owl was contingent upon the effect of cat management upon the hawk-owl.

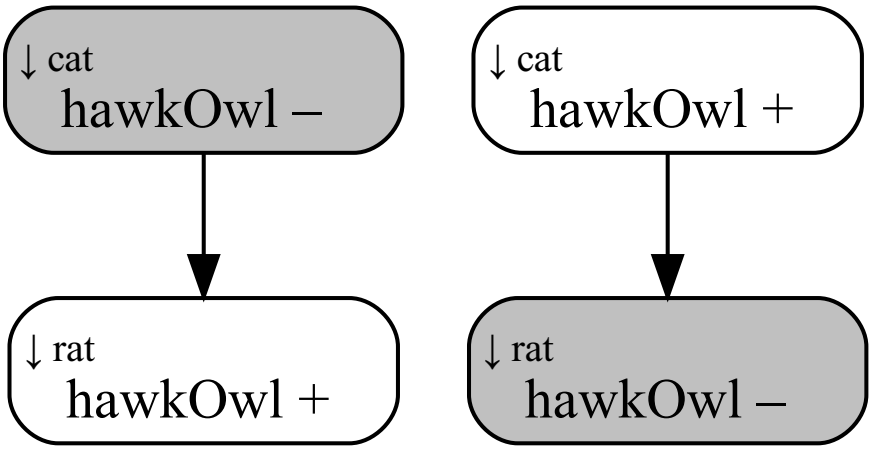
```
edgelist_cr5 <- get_edgelist_certainAnte(PCUList_cr5, c('poscat_hawkOwl', 'negcat_hawkOwl'))
draw_implication_network(edgelist_cr5)
```



Scenario 1b: when cat management has a positive effect on rat population and rat management has a positive effect on cat population (this is a less likely scenario).

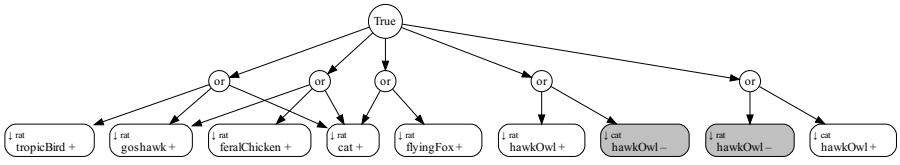
```
PCUList_cr6 = list()
for (PCU in PCUList_cr3){
    if (!('negrat_cat' %in% PCU)){
        PCU <- str_subset(PCU, 'rat_cat', negate = TRUE)
        PCUList_cr6[[length(PCUList_cr6)+1]] <- PCU
    }
}
```

```
edgelist_cr6 <- get_edgelist_certainAnte(PCUList_cr6, c('poscat_hawkOwl', 'negcat_hawkOwl'))
draw_implication_network(edgelist_cr6)
```



Scenario 2: when cat management has a negative effect on rat population.

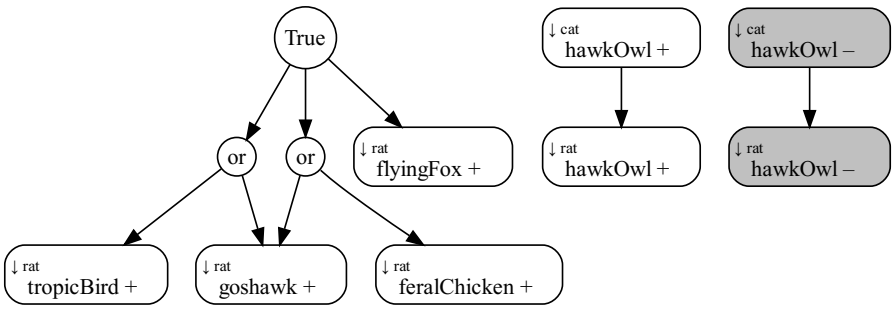
```
edgelist_cr4 <- get_edgelist_certainAnte(PCUList_cr4, c())
draw_implication_network(edgelist_cr4)
```



Scenario 2a: When cat management has a negative effect on rat population and rat management has a negative effect on cat population.

```
PCUList_cr7 = list()
for (PCU in PCUList_cr4){
    if (!('posrat_cat' %in% PCU)){
        PCU <- str_subset(PCU, 'rat_cat', negate = TRUE)
        PCUList_cr7[[length(PCUList_cr7)+1]] <- PCU
    }
}
```

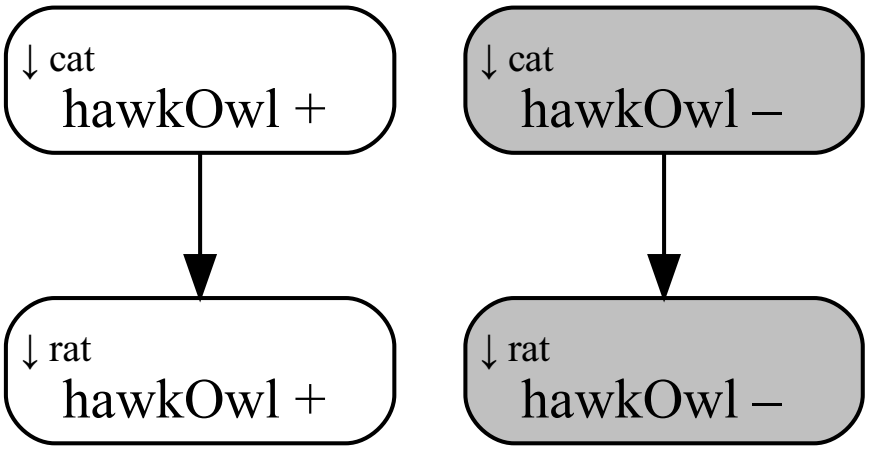
```
edgelist_cr7a <- get_edgelist_certainAnte(PCUList_cr7, c('poscat_hawkOwl', 'negcat_hawkOwl'))
draw_implication_network(edgelist_cr7a)
```



Scenario 2b: when cat management has a negative effect on rat population and rat management has a positive effect on cat population.

```
PCUList_cr8 = list()
for (PCU in PCUList_cr4){
    if (!('negrat_cat' %in% PCU)){
        PCU <- str_subset(PCU, 'rat_cat', negate = TRUE)
        PCUList_cr8[[length(PCUList_cr8)+1]] <- PCU
    }
}
```

```
edgelist_cr8a <- get_edgelist_certainAnte(PCUList_cr8, c('poscat_hawkOwl', 'negcat_hawkOwl'))
draw_implication_network(edgelist_cr8a)
```


↓ cat
hawkOwl +
↓ cat
hawkOwl –
↓ rat
hawkOwl +
↓ rat
hawkOwl –