Sumatriptan versus caffeine for migraine

A decision tree example

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Introduction

This vignette is an example of modelling a decision tree using the `rdecision` package. It is based on the example given by Briggs[1, Box 2.3] which itself is based on a decision tree which compared oral Sumatriptan versus oral caffeine/Ergotamine for migraine.[2]

Creating the model

The following code constructs the decision tree. In the formulation used by `rdecision`, a decision tree is a form of *arborescence*, a directed graph of nodes and edges, with a single root and a unique path from the root to each leaf node. Decision trees comprise three types of node: decision, chance and leaf nodes and two types of edge: actions (whose sources are decision nodes) and reactions (whose sources are chance nodes), Figure 1.

```r
# Time horizon
th <- as.difftime(48, units="hours")

# model variables for cost
c.sumatriptan <- 16.10
c.caffeine <- 1.32
c.ED <- 63.16
c.admission <- 1093

# Sumatriptan branch
ta <- LeafNode$new("A", utility=1.0, interval=th)
tb <- LeafNode$new("B", utility=0.9, interval=th)
c3 <- ChanceNode$new()
e1 <- Reaction$new(c3, ta, p=0.594, label="No recurrence")
e2 <- Reaction$new(c3, tb, p=0.406, cost=c.sumatriptan,
                   label="Relieved 2nd dose")

td <- LeafNode$new("D", utility=0.1, interval=th)
te <- LeafNode$new("E", utility=-0.3, interval=th)
c7 <- ChanceNode$new()
e3 <- Reaction$new(c7, td, p=0.998, label="Relief")
e4 <- Reaction$new(c7, te, p=0.002, cost=c.admission, label="Hospitalization")

tc <- LeafNode$new("C", utility=-0.3, interval=th)
c4 <- ChanceNode$new()
e5 <- Reaction$new(c4, tc, p=0.920, label="Endures attack")
```

```r
e6 <- Reaction$new(c4, c7, p=0.080, cost=c.ED, label="ED")

c1 <- ChanceNode$new()
e7 <- Reaction$new(c1, c3, p=0.558, label="Relief")
e8 <- Reaction$new(c1, c4, p=0.442, label="No relief")

# Caffeine/Ergotamine branch
tf <- LeafNode$new("F", utility=1.0, interval=th)
tg <- LeafNode$new("G", utility=0.9, interval=th)
c5 <- ChanceNode$new()
e9 <- Reaction$new(c5, tf, p=0.703, label="No recurrence")
e10 <- Reaction$new(c5, tg, p=0.297, cost=c.caffeine,
                    label="Relieved 2nd dose")

ti <- LeafNode$new("I", utility=0.1, interval=th)
tj <- LeafNode$new("J", utility=-0.3, interval=th)
c8 <- ChanceNode$new()
e11 <- Reaction$new(c8, ti, p=0.998, label="Relief")
e12 <- Reaction$new(c8, tj, p=0.002, cost=c.admission, label="Hospitalization")

th <- LeafNode$new("H", utility=-0.3, interval=th)
c6 <- ChanceNode$new()
e13 <- Reaction$new(c6, th, p=0.920, label="Endures attack")
e14 <- Reaction$new(c6, c8, p=0.080, cost=c.ED, label="ED")

c2 <- ChanceNode$new()
e15 <- Reaction$new(c2, c5, p=0.379, label="Relief")
e16 <- Reaction$new(c2, c6, p=0.621, label="No relief")

# decision node
d1 <- DecisionNode$new("d1")
e17 <- Action$new(d1, c1, cost=c.sumatriptan, label="Sumatriptan")
e18 <- Action$new(d1, c2, cost=c.caffeine, label="Caffeine/Ergotamine")

# create lists of nodes and edges
V <- list(
  d1, c1, c2, c3, c4, c5, c6, c7, c8,
  ta, tb, tc, td, te, tf, tg, th, ti, tj
)
E <- list(
  e1, e2, e3, e4, e5, e6, e7, e8, e9, e10, e11, e12, e13, e14, e15, e16,
  e17, e18
)
# tree
DT <- DecisionTree$new(V,E)
```

Running the model

The method `evaluate` of decision tree objects computes the probability, cost and utility of each *strategy* for the model. A strategy is a unanimous prescription of the actions at each decision node. In this example there is a single decision node with two actions, and the strategies are simply the two forms of treatment to be compared. More complex decision trees are also possible.
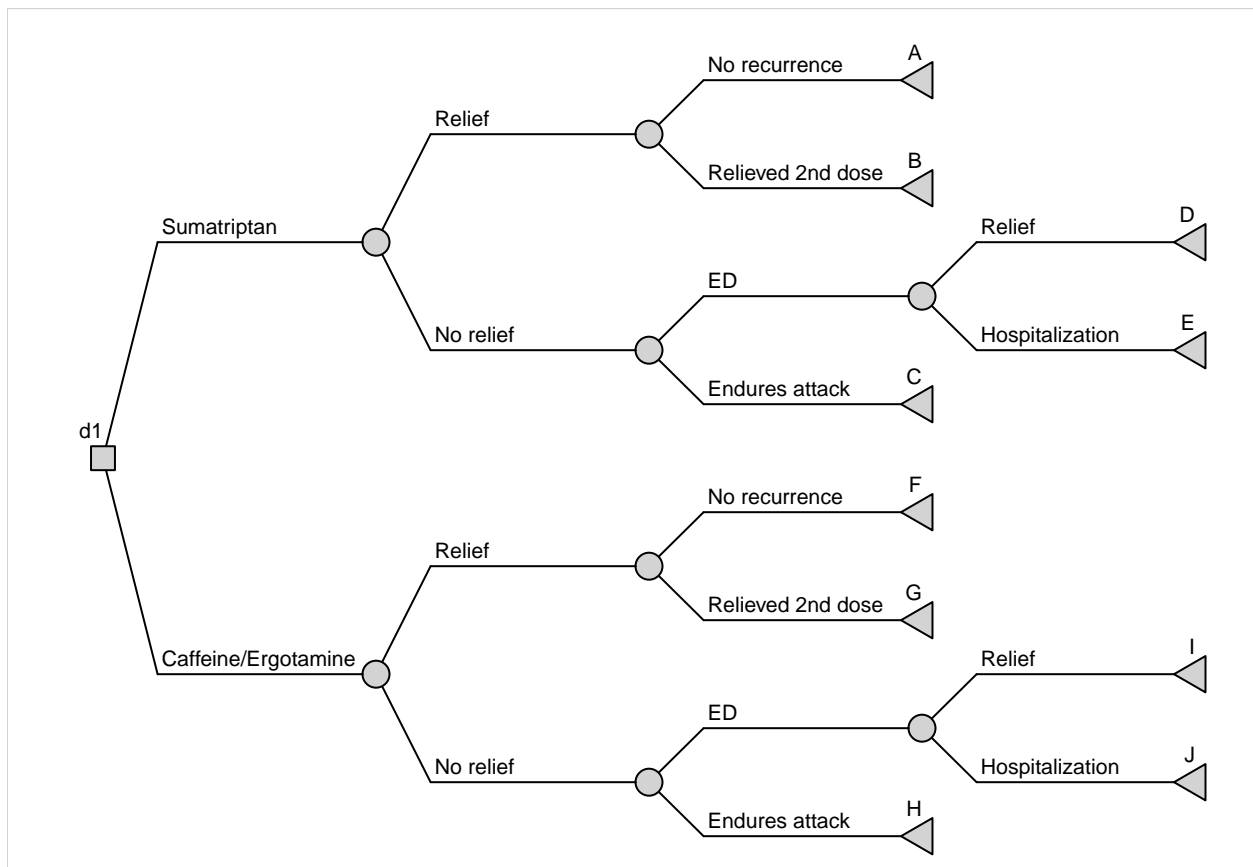
Figure 1: Decision tree for the Sumatriptan model

The paths traversable in each strategy can be evaluated individually using the method `evaluate(by="path")`. In `rdecision` a strategy is defined as a set of action edges with one action edge per decision node. It is necessary to use the option `by="path"` only if information about each pathway is required; normally it is sufficient to call `evaluate` which will automatically aggregate the evaluation by strategy.

Model results

The evaluation of each pathway, for each strategy, yields the following table:

Leaf	d1	Probability	Cost	Utility	QALY
A	Sumatriptan	0.33	5.34	0.33	0.0018
B	Sumatriptan	0.23	7.29	0.20	0.0011
C	Sumatriptan	0.41	6.55	-0.12	-0.0007
D	Sumatriptan	0.04	2.80	0.00	0.0000
E	Sumatriptan	0.00	0.08	0.00	0.0000
F	Caffeine/Ergotamine	0.27	0.35	0.27	0.0015
G	Caffeine/Ergotamine	0.11	0.30	0.10	0.0006
H	Caffeine/Ergotamine	0.57	0.75	-0.17	-0.0009
I	Caffeine/Ergotamine	0.05	3.20	0.00	0.0000
J	Caffeine/Ergotamine	0.00	0.12	0.00	0.0000

There are, as expected, ten pathways (5 per strategy). The expected cost, utility and QALY (utility multiplied by the time horizon of the model) for each choice can be calculated from the table above, or by invoking the `evaluate` method of a decision tree object with the default parameter `by="strategy"`. This gives the following result, consistent with that reported by Evans *et al.*[2]

d1	Cost	Utility	QALY
Caffeine/Ergotamine	4.71	0.20128	0.00110
Sumatriptan	22.06	0.41686	0.00228

References

1   Briggs A, Claxton K, Sculpher M. *Decision modelling for health economic evaluation.* Oxford, UK: Oxford University Press; 2006.

2   Evans KW, Boan JA, Evans JL, Shuaib A. Economic evaluation of oral sumatriptan compared with oral caffeine/ergotamine for migraine. *Pharmacoeconomics* 1997;**12**:565–77.