jRank – Ranking using Dominance-based Rough Set Approach

http://www.cs.put.poznan.pl/mszelag/Software/jRank/jRank.html

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March 1, 2011

General description

jRank is a decision support tool for solving multi-criteria choice and ranking problems. It is a highly configurable command line Java application, based on java Rough Set (jRS) library developed in the `Laboratory of Intelligent Decision Support Systems` (IDSS) at Poznań University of Technology. This library implements methods of data analysis provided by the Dominance-based Rough Set Approach (DRSA) [12, 13, 15] and Variable Consistency Dominance-based Rough Set Approaches (VC-DRSA) [1, 2, 3, 4]. DRSA is designed for problems with background knowledge about ordinal evaluations of objects from a universe, and about monotonic relationships between these evaluations, e.g., "the larger the mass and the smaller the distance, the larger the gravity" or "the greater the debt of a firm, the greater its risk of failure". DRSA also accepts non-ordinal evaluations.

For considered *learning set* of objects A and *test set* of objects T (which can be the same as A), both loaded from text files in `ISF` format [7], the following steps are performed:

1) creation of a *pairwise comparison table* (PCT), on the basis of *preference information* given by the *decision maker* (DM) as *reference ranking* (weak order) on $A^R \subseteq A$ or *pairwise comparisons* of some objects from $A^R \subseteq A$,

2) calculation of *lower* and *upper approximations* of *outranking* relation S and *non-outranking* relation S^c, for PCT created in step 1; approximations are calculated according to DRSA or VC-DRSA,

3) induction of certain (or possible) *decision rules* from lower (or upper) approximations defined in step 2; in order to induce *minimal set of rules*, VC-DomLEM sequential covering algorithm [5, 6] is used; thanks to the adaptation of the idea described in [10], it is also possible to use an *exhaustive set of rules*, without explicit induction of rules (i.e., to use a virtual exhaustive set of rules),

4) application of decision rules to all pairs of objects from $T \times T$, which yields a *preference structure* (graph) in set T,

5) *exploitation* of the preference graph by one of six available *ranking procedures* [9, 11, 14, 16] in order to obtain a final ranking (weak order) in T; this ranking is a solution to the ranking problem; in case of a choice problem, the solution is the set of objects which share the first place in the final ranking.

jRank can be downloaded from the IDSS website. A user's manual describing in detail application of DRSA to multi-criteria choice and ranking problems, describing application of jRank, and presenting an illustrative example, is available on-line at `jRank homepage`.

Illustrative Example

Without going into technical details on how to run jRank, which can be found in the user's manual [7], let us analyze the results obtained for Thierry's choice problem [8], which is a car selection problem, where preference information is given by the DM as a reference ranking on 5 out of 14 cars: $11 \succ 3 \succ 13 \succ 9 \succ 14$.

Experiment configuration file `experiment.properties` [7] used to configure jRank has the following content:

```
learningDataFile = ThierrysChoice.isf
referenceRanking = 11, 3, 13, 9, 14
objectConsistencyMeasure = rough-
    membership
objectConsistencyMeasureThreshold = 1.0
```

As a result of jRank run, we obtained the following new text files:

- `ThierrysChoice_partialPCT.isf` – contains PCT created for a given reference ranking,
- `ThierrysChoice_partialPCT.apx` – contains approximations of relations S and S^c in PCT,
- `ThierrysChoice_partialPCT.rules` – contains decision rules generated by VC-DomLEM algorithm,
- `ThierrysChoice.graph` – contains preference graph in a format accepted by `Gvedit` and `dotty` from `Graphviz`,
- `ThierrysChoice.ranking` – contains final ranking (weak order) of considered cars.

In order to create PCT, jRank assumes that car x outranks car y (i.e., xSy) if x is ranked not worse than y. Otherwise, it assumes that x does not outrank y (i.e., xS^cy). Moreover, the pairs of cars from PCT are described by differences of evaluations on considered five criteria: price, accel, pick_up, brakes, and road_h, denoted as $q_1, \ldots, q_5$. Criteria q_1, q_2, q_3 are to be minimized, and q_4, q_5 to be maximized. Table 1 shows just two exemplary rows of created PCT.

Table 1: Part of PCT for Thierry's choice problem

(x, y)	Δ_{q_1}	Δ_{q_2}	Δ_{q_3}	Δ_{q_4}	Δ_{q_5}	Relation
$(11, 3)$	564	-0.7	-0.1	-0.33	0.25	S
$(13, 11)$	-318	1.9	2.1	-0.67	-1.5	S^c

In the generated *.apx file we can see that there are no inconsistent pairwise comparisons (which happens if a pair of objects belonging to relation S^c *dominates* a pair of objects belonging to relation S).

VC-DomLEM algorithm induced the following five certain rules:

1. if price(x) − price(y) ≤ -1534 then xSy,
2. if price(x) − price(y) ≤ 0 and road_h(x) − road_h(y) ≥ 0 then xSy,
3. if price(x) − price(y) ≤ 564 and road_h(x) − road_h(y) ≥ 0.25 then xSy,
4. if price(x) − price(y) ≥ 1534 then xS^cy,
5. if price(x) − price(y) ≥ -564 and road_h(x) − road_h(y) ≤ -0.25 then xS^cy.

Preference graph resulting from application of the five induced rules to all pairs of cars is presented in Fig. 1. Green arcs denote outranking relation S; red arcs denote non-outranking relation S^c. Note that this graph exhibits an internal information which need not to be interpreted by the DM.

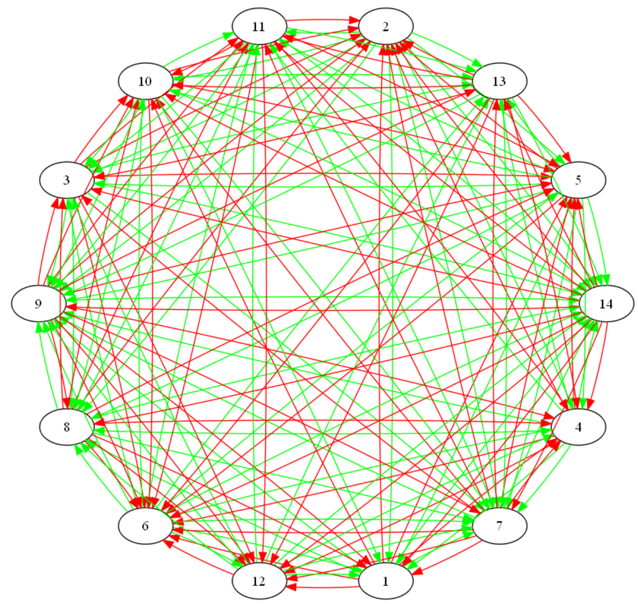

Figure 1: Preference graph for the Thierry's choice problem

Final ranking of considered objects (weak order) is obtained by applying to the preference graph one of six *ranking procedures*. In our example, we applied a default procedure, i.e., the Net Flow Score (NFS) (for the definition see, e.g., [15]). The resulting ranking is presented in Table 2.

Table 2: Final ranking of cars for Thierry's choice problem

rank	cars	net flow score
1:	6	24.0
2:	2	22.0
3:	5, 12	16.0
4:	10	10.0
5:	4	6.0
6:	11	0.0
7:	3	-2.0
8:	1	-4.0
9:	13	-10.0
10:	8	-13.0
11:	7	-17.0
12:	9	-22.0
13:	14	-26.0

The ranking consists of thirteen ranks, ordered according to the net flow score. There is one tie – between car no. 5 and 12.

One can easily observe that the final ranking includes the reference ranking given by the DM on five cars.

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