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Пояснительная записка
к модулю подбора метаконфигураций решателя SCIP для MILP-проблем с «короткой итерацией»

Подвойский А.О

Содержание

1. Вводные замечания

Подбор стратегии поиска решения и гиперпараметров решателя имеет смысл только для MILP-проблем с «короткой итерацией», то есть для проблем, у которых полное время поиска решения не превосходит некоторого порога времени, считающегося приемлемым временем ожидания (например, 30 секунд).

Запуск решателя SCIP с различными комбинациями параметров выполняется параллельно. Фиксируется время поиска решения до достижения заданного значения зазора и значение целевой функции.

Результаты сводятся в таблицу со следующими полями:

- наименование проблемы (`problem_name`),
- количество бинарных переменных до пресолвинга (`n_bin_vars_before_presolving`),
- количество целочисленных переменных до пресолвинга (`n_int_vars_before_presolving`),
- количество вещественных переменных до пресолвинга (`n_cont_vars_before_presolving`),
- количество ограничений до пресолвинга (`n_conss_before_presolving`),
- количество бинарных переменных после пресолвинга (`n_bin_vars_after_presolving`),
- количество целочисленных переменных после пресолвинга (`n_int_vars_after_presolving`),
- количество вещественных переменных после пресолвинга (`n_cont_vars_after_presolving`),
- количество ограничений после пресолвинга (`n_conss_after_presolving`),
- группа гиперпараметров снижения размерности задачи (`group_presolving`); допустимые значения `default`, `aggressive` и `fast`,
- группа гиперпараметров решения проблемы в релаксированной постановке (`group_relax_method`),
- группа гиперпараметров адаптации проблемы (`group_adaptation_problem`),
- группа гиперпараметров точности решения (`group_tol`)

2. Предложения по формированию пространства гиперпараметров решателя

Не все гиперпараметры решателя имеет смысл подбирать «изолировано». К примеру, следующий набор гиперпараметров с указанными значениями имеет смысл только для *агрессивного пресолвинга*

```
presolving/restartfac = 0.0125
presolving/restartminred = 0.06
constraints/setppc/cliquelifting = TRUE
presolving/boundshift/maxrounds = -1
presolving/qpkktref/maxrounds = -1
presolving/stuffing/maxrounds = -1
presolving/tworowbnd/maxrounds = -1
presolving/dualinfer/maxrounds = -1
presolving/dualagg/maxrounds = -1
presolving/redvub/maxrounds = -1
propagating/probing/maxuseless = 1500
propagating/probing/maxtotaluseless = 75
```

Таким образом, предлагается выделить следующие группы гиперпараметров решателя, объединенные по целевому контексту:

1. *Группа гиперпараметров снижения размерности задачи* (`presolving`):
   - По умолчанию (`DEFAULT`)

     ```
     # PySCIPOpt
     model.setPresolve(pyscipopt.SCIP_PARAMSETTING.DEFAULT)
     ```

   - Агрессивное (`AGGRESSIVE`)

     ```
     # PySCIPOpt
     model.setPresolve(pyscipopt.SCIP_PARAMSETTING.AGGRESSIVE)
     ```

     ```
     # ЗНАЧЕНИЯ ПАРАМЕТРОВ НЕ ИЗМЕНЯЮТСЯ
     # SCIP> set presolving emphasis aggr
     presolving/restartfac = 0.0125
     presolving/restartminred = 0.06
     constraints/setppc/cliquelifting = TRUE
     presolving/boundshift/maxrounds = -1
     presolving/qpkktref/maxrounds = -1
     presolving/stuffing/maxrounds = -1
     presolving/tworowbnd/maxrounds = -1
     presolving/dualinfer/maxrounds = -1
     presolving/dualagg/maxrounds = -1
     presolving/redvub/maxrounds = -1
     propagating/probing/maxuseless = 1500
     propagating/probing/maxtotaluseless = 75
     ```

   - Быстрое (`FAST`)

     ```
     # PySCIPOpt
     model.setPresolve(pyscipopt.SCIP_PARAMSETTING.FAST)
     ```

     ```
     # ЗНАЧЕНИЯ ПАРАМЕТРОВ НЕ ИЗМЕНЯЮТСЯ
     # SCIP> set presolving emphasis fast
     constraints/varbound/presolpairwise = FALSE
     constraints/knapsack/presolpairwise = FALSE
     ```

```
constraints/setppc/presolpairwise = FALSE
constraints/and/presolpairwise = FALSE
constraints/xor/presolpairwise = FALSE
constraints/linear/presolpairwise = FALSE
constraints/logicor/presolpairwise = FALSE
constraints/cumulative/presolpairwise = FALSE
presolving/maxrestarts = 0
propagating/probing/maxprerounds = 0
constraints/components/maxprerounds = 0
presolving/domcol/maxrounds = 0
presolving/gateextraction/maxrounds = 0
presolving/sparsify/maxrounds = 0
presolving/dualsparsify/maxrounds = 0
constraints/logicor/implications = FALSE
```

2. *Группа гиперпараметров решения проблемы в релаксированной постановке*

```
lp/initalgorithm = s'implex  # default
                 = p'rimal simplex
                 = d'ual simplex
                 = b'arrier
                 = barrier with c'rossover
randomization/lpseed = 0  # default
```

3. *Группа гиперпараметров ветвления и разрешения конфликтов*

```
# Эти параметры <<включаются>> и <<выключаются>> только в паре
conflict/preferbinary = TRUE | FALSE
branching/preferbinary = TRUE | FALSE
```

4. *Группа гиперпараметров адаптации проблемы*

   - easycip

```
# ЗНАЧЕНИЯ ПАРАМЕТРОВ НЕ ИЗМЕНЯЮТСЯ
# PySCIPOpt: model.setEmphasis(pyscipopt.SCIP_PARAMEMPHASIS.EASYCIP)
# SCIP> set emph easycip
# predefined parameter settings for easy problems
heuristics/clique/freq = -1
heuristics/completesol/freq = -1
heuristics/crossover/freq = -1
heuristics/gins/freq = -1
heuristics/locks/freq = -1
heuristics/lpface/freq = -1
heuristics/alns/freq = -1
heuristics/multistart/freq = -1
heuristics/mpec/freq = -1
heuristics/ofins/freq = -1
heuristics/padm/freq = -1
heuristics/rens/freq = -1
heuristics/rins/freq = -1
heuristics/undercover/freq = -1
heuristics/vbounds/freq = -1
heuristics/distributiondiving/freq = -1
heuristics/feaspump/freq = -1
heuristics/fracdiving/freq = -1
heuristics/guideddiving/freq = -1
heuristics/linesearchdiving/freq = -1
heuristics/nlpdiving/freq = -1
heuristics/subnlp/freq = -1
heuristics/objpscostdiving/freq = -1
```

```
heuristics/pscostdiving/freq = -1
heuristics/rootsoldiving/freq = -1
heuristics/veclendiving/freq = -1
constraints/varbound/presolpairwise = FALSE
constraints/knapsack/presolpairwise = FALSE
constraints/setppc/presolpairwise = FALSE
constraints/and/presolpairwise = FALSE
constraints/xor/presolpairwise = FALSE
constraints/linear/presolpairwise = FALSE
constraints/logicor/presolpairwise = FALSE
constraints/cumulative/presolpairwise = FALSE
presolving/maxrestarts = 0
propagating/probing/maxprerounds = 0
constraints/components/maxprerounds = 0
presolving/domcol/maxrounds = 0
presolving/gateextraction/maxrounds = 0
presolving/sparsify/maxrounds = 0
presolving/dualsparsify/maxrounds = 0
constraints/logicor/implications = FALSE
separating/maxbounddist = 0
constraints/and/sepafreq = 0
separating/aggregation/maxroundsroot = 5
separating/aggregation/maxtriesroot = 100
separating/aggregation/maxaggrsroot = 3
separating/aggregation/maxsepacutsroot = 200
separating/zerohalf/maxsepacutsroot = 200
separating/zerohalf/maxroundsroot = 5
separating/gomory/maxroundsroot = 20
separating/mcf/freq = -1
```

- feasibility

```
# ЗНАЧЕНИЯ ПАРАМЕТРОВ НЕ ИЗМЕНЯЮТСЯ
# PySCIPOpt: model.setEmphasis(pyscipopt.SCIP_PARAMEMPHASIS.FEASIBILITY)
# SCIP> set emph feas
# predefined parameter settings for feasibility problems
heuristics/actconsdiving/freq = 20
heuristics/adaptivediving/freq = 3
heuristics/adaptivediving/maxlpiterquot = 0.15
heuristics/bound/freq = 20
heuristics/clique/freq = 20
heuristics/coefdiving/freq = 20
heuristics/completesol/freq = 20
heuristics/conflictdiving/freq = 5
heuristics/conflictdiving/maxlpiterofs = 1500
heuristics/conflictdiving/maxlpiterquot = 0.225
heuristics/crossover/freq = 15
heuristics/dins/freq = 20
heuristics/distributiondiving/freq = 5
heuristics/distributiondiving/maxlpiterofs = 1500
heuristics/distributiondiving/maxlpiterquot = 0.075
heuristics/dps/freq = 20
heuristics/farkasdiving/freq = 5
heuristics/farkasdiving/maxlpiterofs = 1500
heuristics/farkasdiving/maxlpiterquot = 0.075
heuristics/feaspump/freq = 10
heuristics/feaspump/maxlpiterofs = 1500
heuristics/feaspump/maxlpiterquot = 0.015
heuristics/fixandinfer/freq = 20
heuristics/fracdiving/freq = 5
```

```
heuristics/fracdiving/maxlpiterofs = 1500
heuristics/fracdiving/maxlpiterquot = 0.075
heuristics/gins/freq = 10
heuristics/guideddiving/freq = 5
heuristics/guideddiving/maxlpiterofs = 1500
heuristics/guideddiving/maxlpiterquot = 0.075
heuristics/zeroobj/freq = 20
heuristics/intdiving/freq = 20
heuristics/intshifting/freq = 5
heuristics/linesearchdiving/freq = 5
heuristics/linesearchdiving/maxlpiterofs = 1500
heuristics/linesearchdiving/maxlpiterquot = 0.075
heuristics/localbranching/freq = 20
heuristics/locks/freq = 20
heuristics/lpface/freq = 8
heuristics/alns/freq = 10
heuristics/nlpdiving/freq = 5
heuristics/mutation/freq = 20
heuristics/multistart/freq = 20
heuristics/mpec/freq = 25
heuristics/objpscostdiving/freq = 10
heuristics/objpscostdiving/maxlpiterofs = 1500
heuristics/objpscostdiving/maxlpiterquot = 0.015
heuristics/octane/freq = 20
heuristics/ofins/freq = 20
heuristics/padm/freq = 20
heuristics/proximity/freq = 20
heuristics/pscostdiving/freq = 5
heuristics/pscostdiving/maxlpiterofs = 1500
heuristics/pscostdiving/maxlpiterquot = 0.075
heuristics/randrounding/freq = 10
heuristics/rens/freq = 20
heuristics/reoptsols/freq = 20
heuristics/repair/freq = 20
heuristics/rins/freq = 13
heuristics/rootsoldiving/freq = 10
heuristics/rootsoldiving/maxlpiterofs = 1500
heuristics/rootsoldiving/maxlpiterquot = 0.015
heuristics/shiftandpropagate/freq = 20
heuristics/shifting/freq = 5
heuristics/trivial/freq = 20
heuristics/trivialnegation/freq = 20
heuristics/trustregion/freq = 20
heuristics/twoopt/freq = 20
heuristics/undercover/freq = 20
heuristics/vbounds/freq = 20
heuristics/veclendiving/freq = 5
heuristics/veclendiving/maxlpiterofs = 1500
heuristics/veclendiving/maxlpiterquot = 0.075
heuristics/rens/nodesofs = 2000
heuristics/rens/minfixingrate = 0.3
heuristics/crossover/nwaitingnodes = 20
heuristics/crossover/dontwaitatroot = TRUE
heuristics/crossover/nodesquot = 0.15
heuristics/crossover/minfixingrate = 0.5
heuristics/alns/trustregion/active = TRUE
heuristics/alns/nodesquot = 0.2
heuristics/alns/nodesofs = 2000
separating/maxrounds = 1
separating/maxroundsroot = 5
```

```
separating/aggregation/freq = -1
separating/mcf/freq = -1
nodeselection/restartdfs/stdpriority = 536870911
```

- optimality

```
# ЗНАЧЕНИЯ ПАРАМЕТРОВ НЕ ИЗМЕНЯЮТСЯ
# PySCIPOpt: model.setEmphasis(pyscipopt.SCIP_PARAMEMPHASIS.OPTIMALITY)
# SCIP> set emph opt
# predefined parameter settings for proving optimality fast
separating/closecuts/freq = 0
separating/rlt/freq = 20
separating/rlt/maxroundsroot = 15
separating/disjunctive/freq = 20
separating/disjunctive/maxroundsroot = 150
separating/gauge/freq = 0
separating/interminor/freq = 0
separating/convexproj/freq = 0
separating/gomory/maxroundsroot = 15
separating/gomory/maxsepacutsroot = 400
separating/aggregation/maxsepacutsroot = 1000
separating/clique/freq = 20
separating/zerohalf/maxroundsroot = 30
separating/zerohalf/maxsepacutsroot = 200
separating/mcf/freq = 20
separating/mcf/maxsepacutsroot = 400
separating/eccuts/freq = 0
separating/eccuts/maxroundsroot = 375
separating/eccuts/maxsepacutsroot = 100
separating/oddcycle/freq = 0
separating/oddcycle/maxroundsroot = 15
separating/oddcycle/maxsepacutsroot = 10000
constraints/benderslp/sepafreq = 0
constraints/integral/sepafreq = 0
constraints/SOS2/sepafreq = 10
constraints/varbound/sepafreq = 10
constraints/knapsack/sepafreq = 10
constraints/knapsack/maxsepacutsroot = 500
constraints/setppc/sepafreq = 10
constraints/or/sepafreq = 10
constraints/xor/sepafreq = 10
constraints/conjunction/sepafreq = 0
constraints/disjunction/sepafreq = 0
constraints/linear/sepafreq = 10
constraints/linear/maxsepacutsroot = 500
constraints/orbitope/sepafreq = 0
constraints/logicor/sepafreq = 10
constraints/bounddisjunction/sepafreq = 0
constraints/benders/sepafreq = 0
constraints/pseudoboolean/sepafreq = 0
constraints/superindicator/sepafreq = 0
constraints/countsols/sepafreq = 0
constraints/components/sepafreq = 0
cutselection/hybrid/minorthoroot = 0.1
separating/maxroundsrootsubrun = 5
separating/maxaddrounds = 5
separating/maxcutsroot = 5000
constraints/linear/separateall = TRUE
separating/aggregation/maxfailsroot = 200
separating/mcf/maxtestdelta = -1
```

```
separating/mcf/trynegscaling = TRUE
branching/fullstrong/maxdepth = 10
branching/fullstrong/priority = 536870911
branching/fullstrong/maxbounddist = 0
branching/relpscost/sbiterquot = 1
branching/relpscost/sbiterofs = 1000000
branching/relpscost/maxreliable = 10
branching/relpscost/usehyptestforreliability = TRUE
```

- hardlp

```
# ЗНАЧЕНИЯ ПАРАМЕТРОВ НЕ ИЗМЕНЯЮТСЯ
# PySCIPOpt: model.setEmphasis(pyscipopt.SCIP_PARAMEMPHASIS.HARDLP)
# SCIP> set emph hardlp
# predefined parameter settings for problems with a hard LP
heuristics/clique/freq = -1
heuristics/completesol/freq = -1
heuristics/crossover/freq = -1
heuristics/gins/freq = -1
heuristics/locks/freq = -1
heuristics/lpface/freq = -1
heuristics/alns/freq = -1
heuristics/multistart/freq = -1
heuristics/mpec/freq = -1
heuristics/ofins/freq = -1
heuristics/padm/freq = -1
heuristics/rens/freq = -1
heuristics/rins/freq = -1
heuristics/undercover/freq = -1
heuristics/vbounds/freq = -1
heuristics/distributiondiving/freq = -1
heuristics/feaspump/freq = -1
heuristics/fracdiving/freq = -1
heuristics/guideddiving/freq = -1
heuristics/linesearchdiving/freq = -1
heuristics/nlpdiving/freq = -1
heuristics/subnlp/freq = -1
heuristics/objpscostdiving/freq = -1
heuristics/pscostdiving/freq = -1
heuristics/rootsoldiving/freq = -1
heuristics/veclendiving/freq = -1
constraints/varbound/presolpairwise = FALSE
constraints/knapsack/presolpairwise = FALSE
constraints/setppc/presolpairwise = FALSE
constraints/and/presolpairwise = FALSE
constraints/xor/presolpairwise = FALSE
constraints/linear/presolpairwise = FALSE
constraints/logicor/presolpairwise = FALSE
constraints/cumulative/presolpairwise = FALSE
presolving/maxrestarts = 0
propagating/probing/maxprerounds = 0
constraints/components/maxprerounds = 0
presolving/domcol/maxrounds = 0
presolving/gateextraction/maxrounds = 0
presolving/sparsify/maxrounds = 0
presolving/dualsparsify/maxrounds = 0
constraints/logicor/implications = FALSE
branching/relpscost/maxreliable = 1
branching/relpscost/inititer = 10
separating/maxrounds = 1
```

```
separating/maxroundsroot = 5
```

5. *Группа гиперпараметров точности решения (для численно нестабильных проблем)*

```
numerics/feastol = 1e-05
numerics/dualfeastol = 1e-06
numerics/epsilon = 1e-07
numerics/sumepsilon = 1e-05
```

Список иллюстраций

Список литературы

1. *Жерон, О.* Прикладное машинное обучение с помощью Scikit-Learn и TensorFlow: концепции, инструменты и техники для создания интеллектуальных систем. – СПб.: ООО «Альфа-книга», 2018. – 688 с.
2. *Soenen J. etc.* The Effect of Hyperparameter Tuning on the Comparative Evaluation of Unsupervised Anomaly Detection Methods, 2021