

ACS and MMAS for the Permutation Flow Shop Problem with Weighted Tardiness

Swarm Intelligence project

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Project: ACO Algorithms for PFSP-WT

- 1. Algorithms and implementation**
- 2. Adding local search routine**
- 3. Results and comparisons**
- 4. Conclusion**

- ▶ Schedule construction by exploiting with probability q_0 :
 - ▶ Exploit. best schedule: $\operatorname{argmax}_{\text{unscheduled}} (\tau_{ij})^\alpha (\eta_{ij})^\beta$
 - ▶ Biased exploration: $p_{ij} = \frac{(\tau_{ij})^\alpha (\eta_{ij})^\beta}{\sum_{\text{unscheduled}} (\tau_{ij})^\alpha (\eta_{ij})^\beta}$
- ▶ Earliest Due Dates (EDD) heuristic for initialization: Sort by due dates and $\eta_{ij} = 1/d_i$
- ▶ Global pheromone update applied only by best-iteration ant (using ρ for evaporation)

ACS

- ▶ Include local pheromone update during ant's solution build (using ξ)
- ▶ τ_0 based on EDD solution

MMAS

- ▶ $q_0 = 0$: only explore
- ▶ Pheromone interval:
 $\tau_{min} \leq \tau_{ij} \leq \tau_{max}$
- ▶ Interval updated at each iteration based on current best solution

Local search performed using exhaustive *insertion-moves*:

- ▶ That is for all permutation (i, j) , remove job from position i and insert it in position j
- ▶ Performs in $O(n^2)$ for a schedule

Two mechanisms implemented:

- ▶ *best-ant*: Only best-iteration ant can perform local search: $O(n^2)$ per iteration
- ▶ *all-ant*: All ant can perform local search: $O(mn^2)$ per iteration

- ▶ Because local search routine appears to have a big impact on solution quality, we compare the results of the following 6 algorithms:
 - ▶ ACS
 - ▶ MMAS
 - ▶ ACS-LS-BEST (ALB)
 - ▶ ACS-LS-ALL (ALA)
 - ▶ MMAS-LS-BEST (MLB)
 - ▶ MMAS-LS-ALL (MLA)
- ▶ Execution of each algorithm on each instance 10 times
- ▶ One execution = 30 seconds time budget

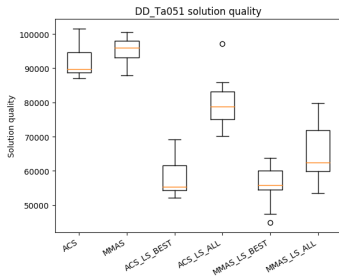
Best configurations parameters returned by `irace` for each algorithm

| | ACS | MMAS | ALB | ALA | MLB | MLA |
|----------|------|------|------|------|------|------|
| ants | 41 | 28 | 5 | 93 | 34 | 87 |
| α | 2.56 | 3.88 | 2.83 | 3.69 | 4.41 | 0.34 |
| β | 7.78 | 6.69 | 3.28 | 5.08 | 9.48 | 6.76 |
| ρ | 0.32 | 0.53 | 0.61 | 0.05 | 0.41 | 0.7 |
| ξ | 0.46 | - | 0.38 | 0.77 | - | - |
| q_0 | 0.07 | - | 0.04 | 0.24 | - | - |

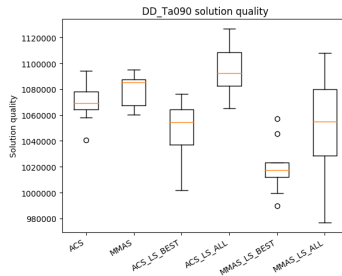
Observations:

- ▶ When *all-ant* is used, `irace` returns nearly max. of ants
- ▶ q_0 mostly very low, exploration seems to perform better
- ▶ Heuristic desirability has bigger impact than pheromone trails

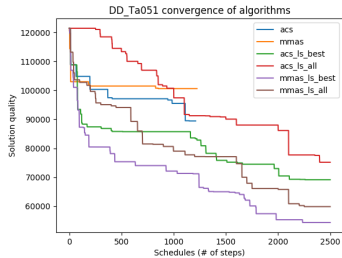
Instance with 50 jobs



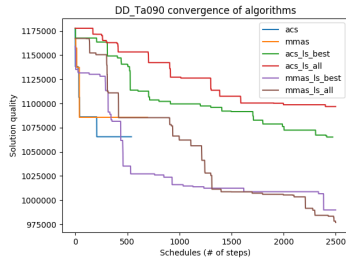
Instance with 100 jobs



Instance with 50 jobs



Instance with 100 jobs



- ▶ Best results repartition for all 20 instances
 - ▶ ACS: 0%
 - ▶ MMAS: 0%
 - ▶ ACS-LS-BEST: 40%
 - ▶ ACS-LS-ALL: 0%
 - ▶ MMAS-LS-BEST: 35%
 - ▶ MMAS-LS-ALL: 25%

- ▶ Intuitive observations
 - ▶ *best-ant* local search seems to always performs better
 - ▶ MMAS-LS-BEST seems better for instances with fewer jobs and ACS-LS-BEST for instances with more jobs
- ▶ Improvements
 - ▶ No parameters analysis..
 - ▶ No analysis of MMAS stagnation and parameters reinitialization

Thank you!

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