Parametrical Adjusting of a Hybrid System for the Vehicle Routing Problem with Time Windows

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Resume

- Brief overview about the problem
- Hybrid System used to parametrical adjusting
- Parametrical Adjusting with statistical framework
- Results
- Conclusions

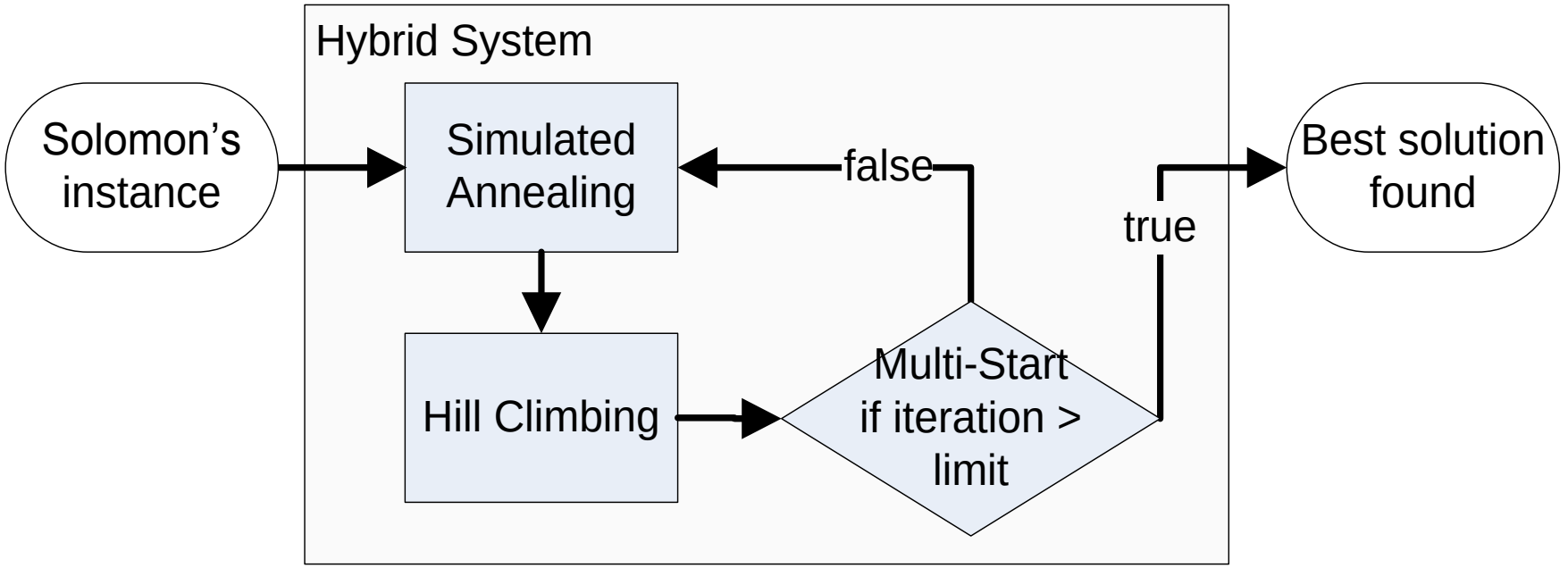
Vehicle Routing Problem with Time Windows (VRPTW): **A general vision**

- It's necessary to produce a scheduling of vehicles showing the service order to minimize transportation costs.
- This work considers the total distance as the main responsible by transportation costs.
- Otherwise, other works consider the number of vehicles used.

Some applications to VRPTW

- School transportation;
- Pickup services, i.e.:
  - garbage collection in urban centers;
- Delivery services, i.e.:
  - food distribution;

Hybrid System (HS) used to solve VRPTW



[Oliveira et Al., 2006]

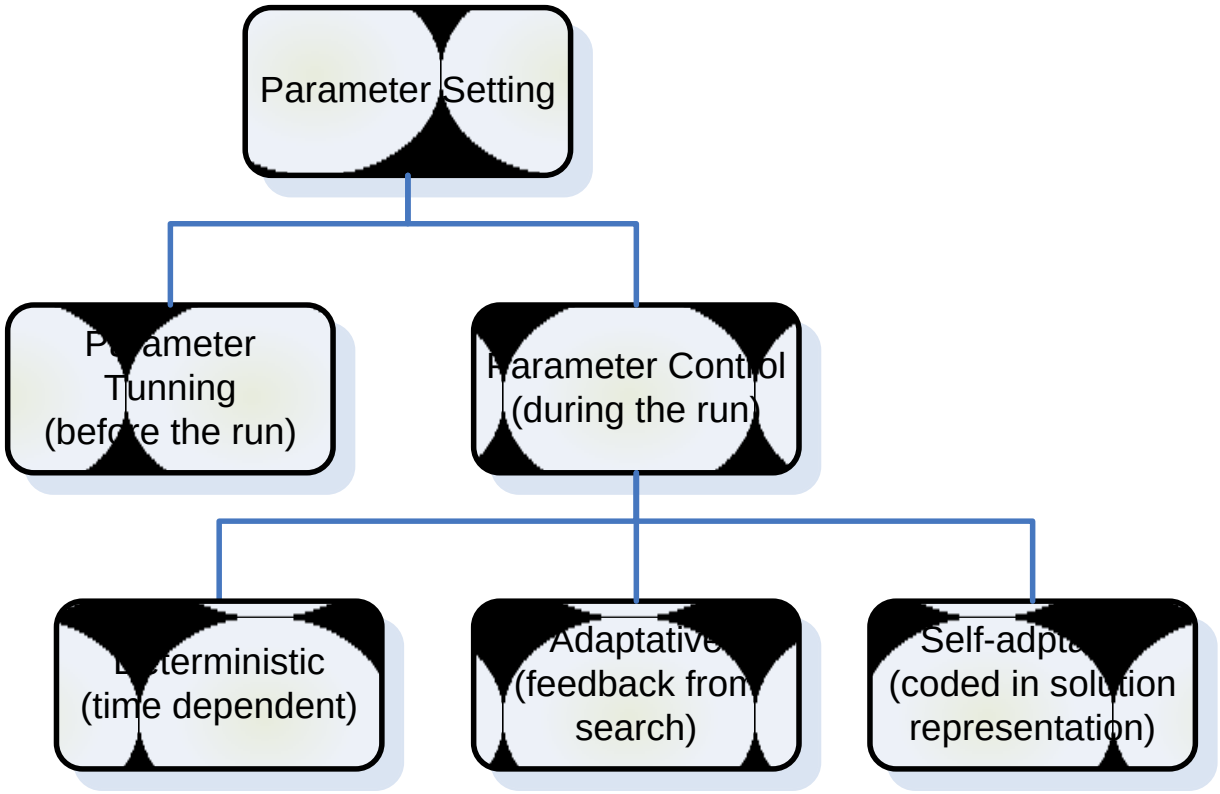
Aims of HS

- Effectiveness (good mean)
- Efficiency (good standard deviation)

How to improve HS?

- Adjusting its parameters…

Parameters Improvement: A classic taxonomy



[Eiben & Smith, 2003]

The statistical framework to parameters adjusting (step by step)

- 1st: Analyze parameters variance;
- 2nd: Apply Linear Regression (LR) in important parameters;
- 3nd: Adjust parameters with LR feedback;
- 4nd: Evaluate the new parameters set;
- 5nd: If necessary, go to step 1;

Applying framework: 1st step: Analysis of Variance

- 3 studied HS parameters
- Where:
  - **P**
    - % application of local search operator, where the variable domain is [0, 100].
  - **FR**
    - reduction Factor of Simulated Annealing temperature, where the variable domain is [0, 1].
  - **TR**
    - reheating of Simulated Annealing temperature, where the variable domain is positives real numbers .

Applying framework: 1st step: Analysis of Variance

- Model: P + FR + TR + P*FR + P*TR + FR*TR + P*FR*TR

Table 1 Synopsis of the analysis of variance on the parameters of the hybrid system

Factor	*p-value*
P	**1.163×10^{-11}**
FR	**9.710×10^{-05}**
TR	0.517474
P:FR	**0.008894**
P:TR	0.202591
FR:TR	0.457425
P:FR:TR	0.385875

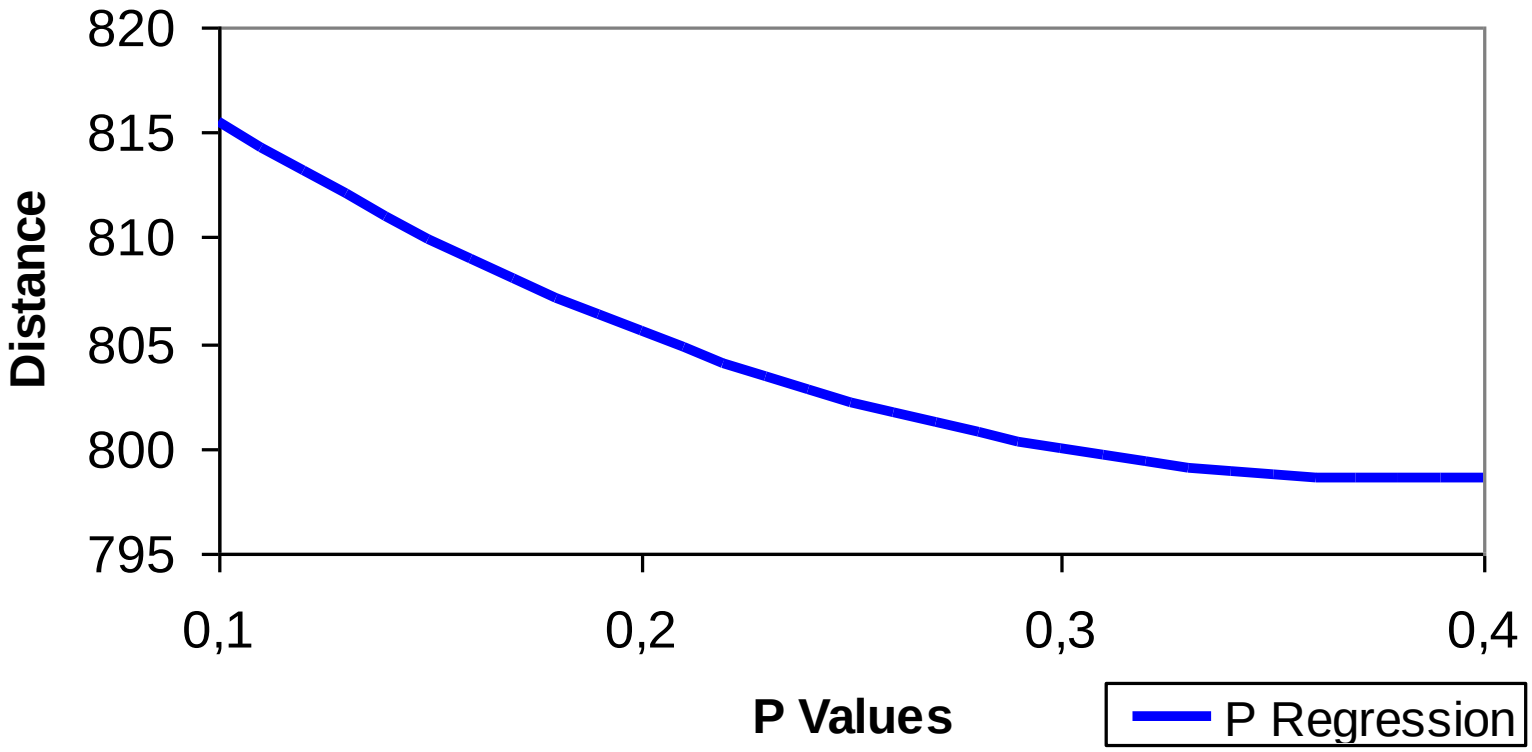
Applying framework: 2nd step: Linear Regression

- ANOVA feedback was used to initialize LR:
  - "P and FR are important parameters to HS"

- **The LR is applied only in the most important parameters.**

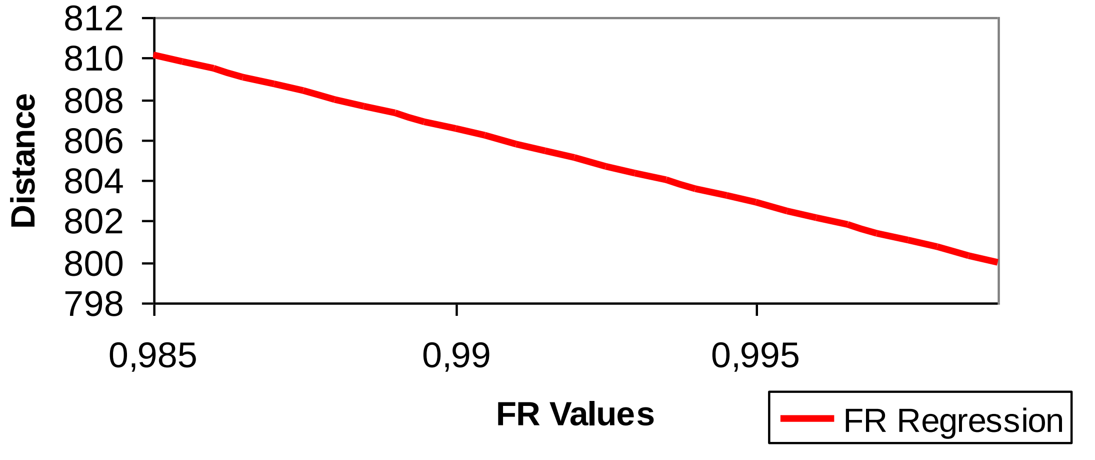
Applying framework: 2nd step: Linear Regression

- LR in parameter P, where the LR has reached a quadratic polynomial. (confidence: 95%)



Applying framework: 2nd step: Linear Regression

- LR in parameter FR:
  - The LR hasn't reached a quadratic polynomial with 95% confidence.



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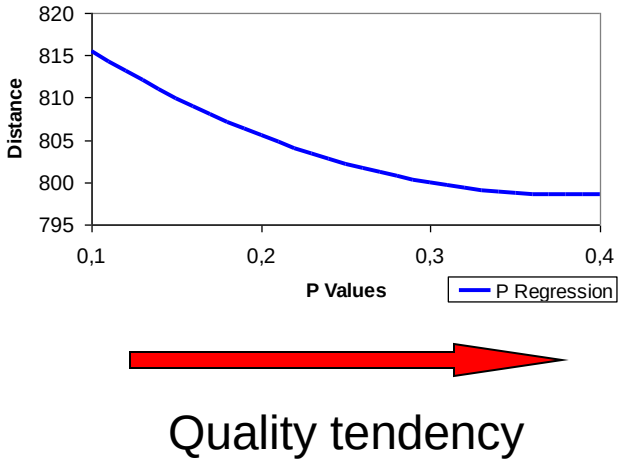
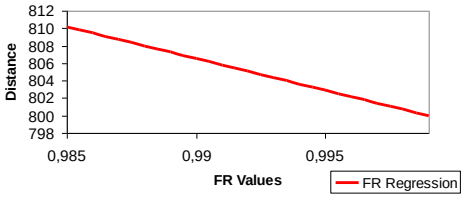
Applying framework: 3nd step: Adjust parameters with LR feedback

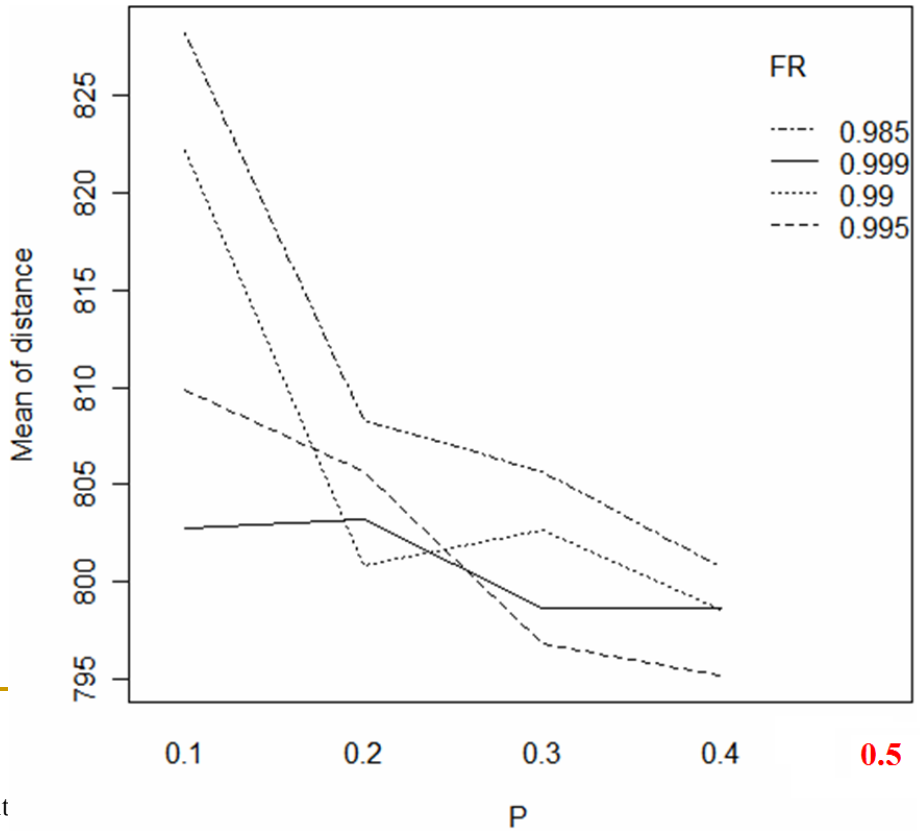
- P:
  - P=0.5 was chosen because of quality stabilization with P > 0.4



Applying framework: 3nd step: Adjust parameters with LR feedback

- FR: FR = 0.995
  - the mean distance was used to find a function of interaction between parameters *P* and *FR*





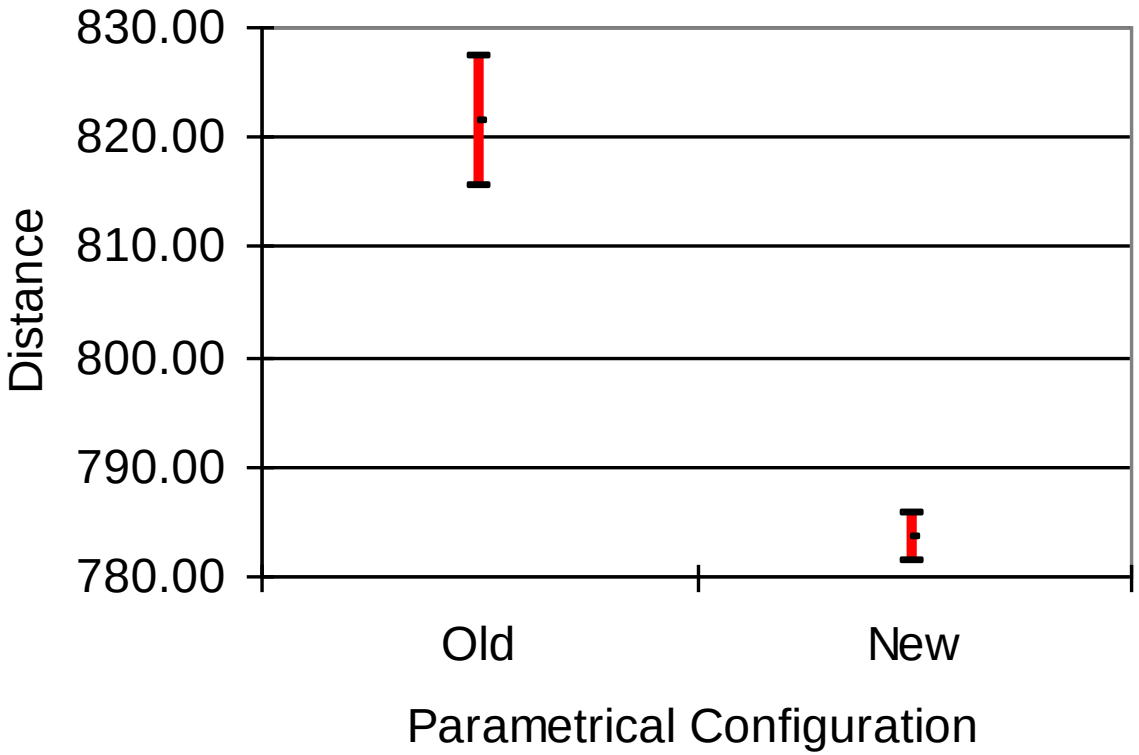
Quality tendency ???

Applying framework: 3nd step: Adjust parameters with LR feedback

- New parametrical values:
  - P = 0.5 (extrapolated value)
  - FR = 0,995 (the best value to P=0.4)
  - TR = 25 (not relevant to quality, by ANOVA)

Applying framework: 4nd step: Evaluate the new parameters set

- Evaluate: comparison between old parameters and new parameters values through confidence interval (confidence: 95%)



Applying framework: 4nd step: Evaluate the new parameters set

- The new configuration was able to produce the new best known result in literature for the analyzed instance:
  - [Solomon, 1987]: VRPTW Benchmark
    - Instance: RC208
      - The best known result : 780.81 un. [Oliveira et Al., 2006]
      - New reached mark: **778.92 un**. [this work]

Main Conclusions

- The Hybrid System improvement was reached with the proposed statistical framework;
- The new Hybrid System is a robust and reliable method.
- The framework can be extended by specializing the described methods.

References

[Solomon, 1987] M. M. Solomon; Algorithms for the Vehicle Routing and Scheduling Problems with Time Window Constraints, *Operations Research*, Vol. 35, No. 2 (1987), pp. 254-265.

[Eiben & Smith, 2003] E. Eiben; J. E. Smith. *Introduction to Evolutionary Computing*. Natural Computing Series. MIT Press. Springer. Berlin. (2003).

[Oliveira et Al., 2006] Oliveira, H.C.B., Vasconcelos, G.C., Alvarenga, G.B., Reducing Traveled Distance in the Vehicle Routing Problem with Time Window using a Multi-Start Simulated Annealing, *International Joint Conference on Neural Networks* (IJCNN'06), Vancouver-CA (2006).

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