Cooperation between Human and Machine for Shop Scheduling Under Uncertainties

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HOPS Conference 2008
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Introduction

Group sequencing:

- is a scheduling method;
- describes a set of schedules;
- guarantees a minimal quality corresponding to the worst case.

A better human-machine system for the execution of the schedule can be done.
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Group Sequencing:

- provides sequential flexibility during the execution of the schedule;
- guarantees a minimal quality corresponding to the worst case.

To manage sequential flexibility, usage of “groups of permutable operations.”
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To manage sequential flexibility, usage of “groups of permutable operations.”
Example: a Job Shop Problem

$i$: the index of the operations, $\Gamma^-(i)$: the set of the predecessors of $O_i$, $m_i$: the resource needed by $O_i$, $p_i$: the processing time needed by $O_i$.

### A Job Shop Problem

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### A Solution to This Problem

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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**A Solution to This Problem**

- \(M_1\): Operations 1 and 8
- \(M_2\): Operations 4, 2, and 9
- \(M_3\): Operations 7, 3, and 5
Execution of the Example

The Group Sequence

![Graph showing the group sequence]

The Corresponding Semi-Active Schedules

![Graphs showing the corresponding semi-active schedules]

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Cooperation for Scheduling Under Uncertainties
Why is Group Sequencing Interesting?

Why is group sequencing interesting?

- proactive reactive method;
- flexibility on sequences;
- widely studied in the last twenty years:
  [Erschler and Roubellat, 1989, Wu et al., 1999, Artigues et al., 2005]
- no need to model the uncertainties;
- the method is able to absorb some uncertainties:
  [Wu et al., 1999, Esswein, 2003, Pinot et al., 2007];
- evaluation of the group sequence in the worst case in polynomial time for minmax regular objectives as $C_{\text{max}}$ and $L_{\text{max}}$.
- evaluation of the group sequence in the best-case is feasible for any regular objective [Pinot and Mebarki, 2008].

A better human-machine system can be done for the reactive phase.
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ORABAID method is:

- the first system using group sequencing;
- used in the ORDO software [Roubellat et al., 1995];
- the only system used in real manufacturing systems.
Description of the human-machine system

The human-machine system for the reactive phase is based on the free sequential margin:

- free margin adapted for group sequencing;
- easily computable;
- allow to monitor the satisfaction of the deadlines;
- it is recommended to execute the operation with the greatest margin.

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Analysis of the human-machine-system

Advantages:

- The system alerts the human when deadlines must not be satisfied;
- The human makes the decision.

Drawbacks:

- The system recommends a decision;
- The workload to analyze the different decision is very high;
- The human can became inactive.
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Different indicators:

- free sequential margin;
- worst-case quality;
- best-case quality;
- processing time;
- etc.

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Goals of this system

To correct ORABAID’s drawbacks:

- The system does not recommend a decision;
- The machine exposes its knowledge to the human, which should help the human to make the decision;
- The human should became active.
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- it corrects ORABAID’s drawbacks;
- it uses the best-case and the worst-case quality;
- the human should became active.

To validate this proposition, experiments will study different aspects:

- the implication of the operator in the decision;
- the effectiveness of the new decision support system in comparison with the other;
- the usage of the indicators by the operator.

These experiments will be done in collaboration with Clément Guérin and Jean-Michel Hoc.
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Thank you for your attention.
Bibliography I


