A New Test-scenario for Optimization-based Analysis and Training of Human Decision Making

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Introduction

- Computer-based test scenarios are widely spread in Complex Problem Solving
- Need *objective* indicator for participant's performance $\longrightarrow$ use optimization! Compare participant's performance to *optimal* solution [1]
- Tailorshop [2, 3, 4]: one of the most famous test scenarios in CPS, economic simulation in 12 rounds
- Developed in the 1980s by Dörner et al.
- Participants need to take decisions, such as investment, advertising, hiring, prices
- Implementation of Tailorshop uses mathematical model implicitly $\longrightarrow$ can extract a MINLP model, use this model for optimization

MINLP Model

- Model extracted from *Tailorshop* implementation in *GW-Basic*, *but:* implementation from early 1980s contained model errors (*service bug, van bug*)
- Dynamic model with discrete time $k = 0, \ldots, N$ with some integer decisions
- mathematical optimization problem for participant and month $0 \le n_s < N$: x_k

$$
\begin{aligned}
\max_{x,u,s} \quad & F(x_N) = x_N^{OB} \\
\text{s.t.} \quad & x_{k+1} = G(x_k, u_k, s_k, p), & k = n_s \ldots N-1, \\
& 0 \le H(x_k, x_{k+1}, u_k, s_k, p), & k = n_s \ldots N-1, \\
& u_k \in \Omega, & k = n_s \ldots N-1, \\
& x_{n_s} = x_{n_s}^p.
\end{aligned}
\tag{1}
$$

- Goal: find decisions u_k to maximize overall balance at end time
- Series of optimal objective function values $F^*(x_N; n_s)$ for $n_s = 0, \ldots, N-1$
- Compare $F^*(x_N; n_s = k)$ with $F^*(x_N; n_s = k+1)$ $\longrightarrow$ obtain exact value of how much less the participant is still able to obtain, optimal decisions assumed (*How much is still possible*–function)

New Tailorshop Test-Scenario
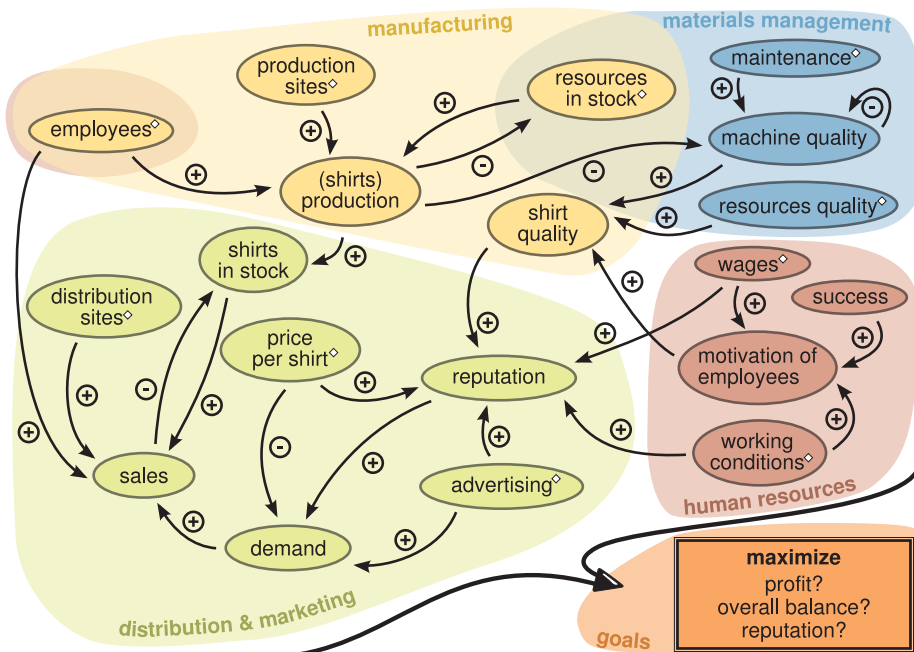
Tailorshop concept with dependencies and positive/negative influences. Diamonds show participants' control possibilities.

Implementation

- implementation with web-based frontend (AJAX, PHP, and MySQL)
- allows for a larger number of participants
- will use AMPL interfaces for optimization — allows, e.g., for usage of *COIN-OR* solvers
- use of optimization for both feedback and analysis of the participant's performance
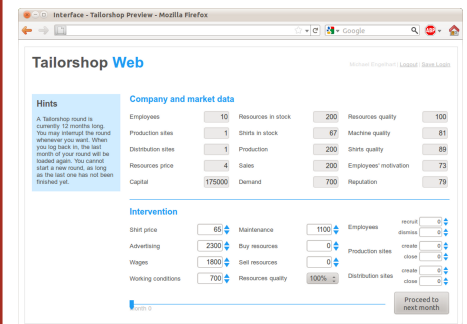
New Tailorshop *Web Interface*

Feedback and Training

- *How much is still possible*–function yields feedback *when* decisions were bad
- But can also determine *which* decisions were bad using Lagrange multipliers
- With fast optimization: compute feedback based on optimal solutions while participant is solving the problems
- How does feedback influence learning?
- How should this feedback be represented?
- Use test scenario with feedback for training

Old Tailorshop-GUI

Outlook

- Include parameter estimation and optimum experimental design
  - First phase: participant has to estimate certain parameter, has to decide when to measure
  - End of first phase: compare estimated value to parameter estimation, compare participant's experiment to optimum experimental design result
  - Second phase: participant has to optimize
- extend to scenarios with continuous time

References

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[2] J. Funke, "Einige Bemerkungen zu Problemen der Problemlöseforschung oder: Ist Testintelligenz doch ein Prädiktor?", *Diagnostica*, vol. 29, pp. 283–302, 1983.

[3] H.-M. Süß, K. Oberauer, and M. Kersting, "Intellektuelle Fähigkeiten und die Steuerung komplexer Systeme", *Sprache & Kognition*, vol. 12, pp. 83–97, 1993.

[4] W. Putz-Osterloh, "Über die Beziehung zwischen Testintelligenz und Problemlöseerfolg", *Zeitschrift für Psychologie*, vol. 189, pp. 79–100, 1981.