

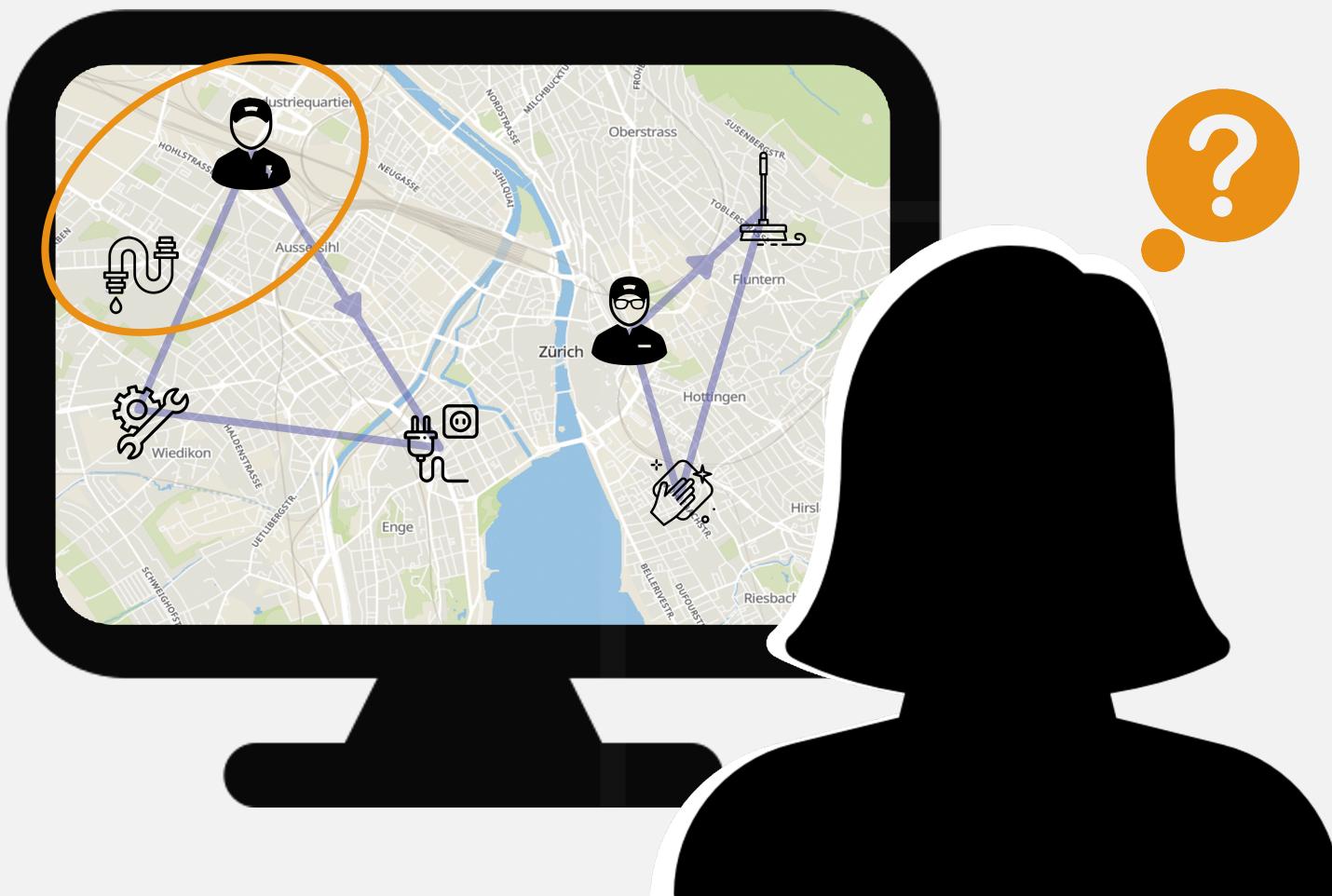
Designing explanation tools for optimization systems Application to the WSRP

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1. Problematic and motivating context



User: "Why is the employee Adam not performing the plumbing task in addition to his two other tasks?"

2. Workforce Scheduling and Routing Problem (WSRP)

Inputs

- $\mathcal{E} = \{\mathcal{E}_i\}_i$ set of employees with:
 - skill levels;
 - working time-windows;
 - locations.
- $\mathcal{T} = \{\mathcal{T}_j\}_j$ set of tasks with:
 - skill levels;
 - availability time-windows;
 - durations $\{d_j\}_j$;
 - locations.
- $\{\Delta t_{jk}^i\}_{ijk}$ set of traveling durations between two locations.

Optimization model

$$\begin{aligned} \max & \left(\underbrace{\sum_{i \in \mathcal{E}} \sum_{j \in \mathcal{T}} \sum_{k \in \mathcal{T}} U_{ijk} d_j}_{\text{total working duration}} - \underbrace{\sum_{i \in \mathcal{E}} \sum_{j \in \mathcal{T}} \sum_{k \in \mathcal{T}} U_{ijk} \Delta t_{jk}^i}_{\text{total traveling duration}} \right) \\ \text{s.t.} & \begin{aligned} & \text{- employees must work within their time windows;} \\ & \text{- tasks must be performed within their time windows;} \\ & \text{- employees must be skilled enough to perform the tasks;} \\ & \dots \end{aligned} \\ U_{ijk} & \in \{0, 1\} \quad \text{whether or not } \mathcal{E}_i \text{ goes from } \mathcal{T}_j \text{ to } \mathcal{T}_k \\ T_j & \in \mathbb{N} \quad \text{performing time of } \mathcal{T}_j \end{aligned}$$

3. Question & explanation in the literature

Questions types

- **Contrastive** (see [1]):

"Why this current decision rather than that other one?"

fact

foil (often implicit)

Explanation reasoning types

- **Counterfactual** (see [2]):

"To get that decision, the input should have been this way."

suggested changes in the input

4. Related work

Article	Domain		Questions		Explanations		User interaction	
	AI	OR ¹	CT ²	Number	CF ³	Dependence on the SA ⁴	Process	GUI ⁵
[3] [4]	-	Scheduling	-	Single template	No	Content-wise: explanation based on data stored during the SA execution		Yes
[5] [6] [7]	Planning	-	Yes	Multiple templates	No	Computation-wise: re-execution of the SA on an altered input	Sequence of independent (question, explanation)	Yes
[2]	-	Selection problems (Knapsack)	Yes	Single template	Yes	Computation-wise: re-executions of the SA on altered inputs		No

1. OR: Operations Research; 2. CT: Contrastive; 3. CF: Counterfactual; 4. SA: Solving Algorithm(s); 5. GUI: Graphic User Interface

5. Our proposals

Domain:

- explanability in OR, similarly to XAI;
- tackling real-world problems (WSRP).

Questions:

multiple templates of contrastive questions.

Explanations:

- not depending on the solving algorithm;
- include counterfactual explanation reasoning.

User interaction:

- dialectical process;
- solutions and instances spaces exploration;
- graphic user interface prototype.

6. Typology of (question, explanation) in our WSRP explanation tool

Type	Contrastive questions			Explanations		
	Templates	Condition	CF ¹	SS ²	CM ³	
(QE ₁)	<ul style="list-style-type: none"> • Why is the employee $\langle \mathcal{E}_i \rangle$ not performing the task $\langle \mathcal{T}_k \rangle$ in addition to the activities of his/her planning? → While keeping the same order of his/her other activities. • ... 	-	No	Small	Linear algorithm based on time slacks	
(QE ₂)	<ul style="list-style-type: none"> • Why is the employee $\langle \mathcal{E}_i \rangle$ not performing the task $\langle \mathcal{T}_k \rangle$ in addition to the activities of his/her planning? → Even if it means changing the order of his/her activities. • ... 	No feasible solution brought out in the explanation of (QE ₁) question	No	Medium	ILP ⁴ restricted to \mathcal{E}_i 's planning	
(QE ₃)	<ul style="list-style-type: none"> • Why is it not possible for the employee $\langle \mathcal{E}_i \rangle$ to perform the task $\langle \mathcal{T}_k \rangle$ in addition to the activities of his/her planning? • ... 	No feasible solution brought out in the explanation of (QE ₂) question	Yes	Large	ILP ⁴ restricted to \mathcal{E}_i 's planning	

1. CF: Counterfactual 2. SS: Solution Set to exam 3. CM: Computation Method 4. ILP: Integer Linear Programming

7. Graphic User Interface of our WSRP explanation tool



8. References

- [1] T. Miller, "Explanation in artificial intelligence : Insights from the social sciences", Artificial Intelligence, 2019.
- [2] A. Korikov et. al., "Counterfactual explanations for optimization-based decisions in the context of the GDPR", IJCAI, 2021
- [3] J. Ludwig et. al., "Explaining Complex Scheduling Decisions", IUI Workshops, 2018
- [4] J. Agrawal et. al. Using Explainable Scheduling for the Mars 2020 Rover Mission, ICAPS Workshop XAIP, 2020
- [5] B. Krarup et. al., "Towards Model-Based Contrastive Explanations for Explainable Planning", ICAPS Workshop XAIP, 2019
- [6] M. Cashmore et. al., "Towards Explainable AI Planning as a Service", ICAPS Workshop XAIP, 2019
- [7] B. Krarup et. al., "Contrastive explanations of plans through model restrictions", arXiv:2103.15575, 2021.