

Designing explanation tools for optimization systems

Application to the WSRP



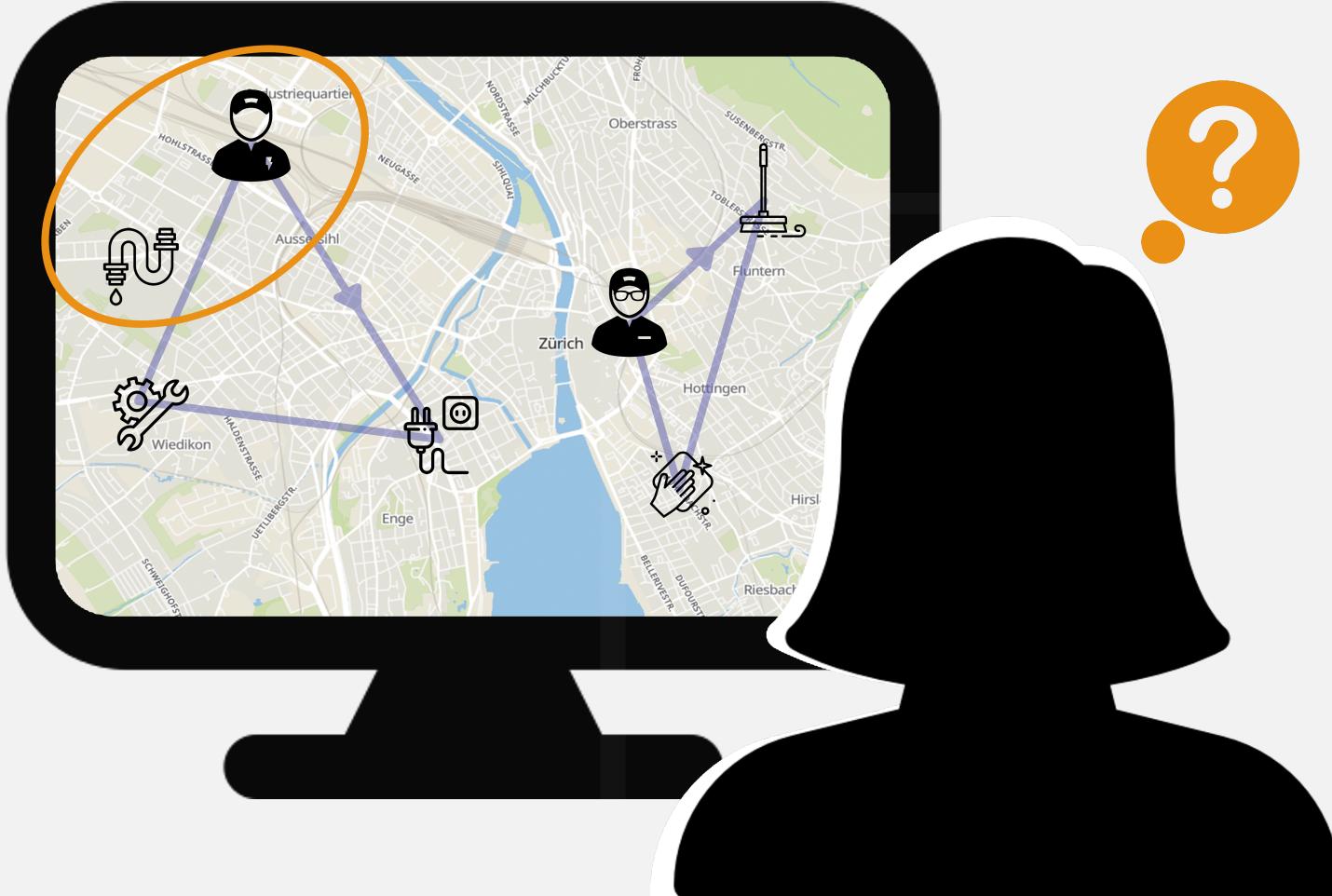
université
PARIS-SACLAY

Mathieu Lerouge^a

Céline Gicquel^b, Vincent Mousseau^a, Wassila Ouerdane^a

^aMICS, CentraleSupélec Université Paris-Saclay, France; ^bLISN, Université Paris-Saclay, France

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.

$$\max \left(\underbrace{\sum_{i \in \mathcal{E}} \sum_{j \in \mathcal{T}} \sum_{k \in \mathcal{T}} U_{ijk} d_j}_{\text{total working duration}}, - \underbrace{\sum_{i \in \mathcal{E}} \sum_{j \in \mathcal{T}} \sum_{k \in \mathcal{T}} U_{ijk} \Delta t_{jk}^i}_{\text{total traveling duration}} \right)$$

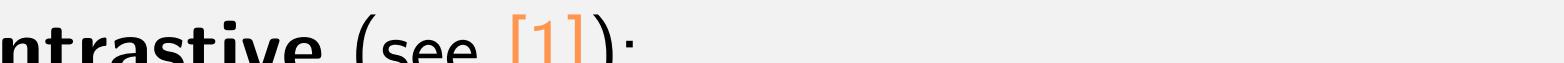
- s.t.

 - employees must work within their time windows;
 - tasks must be performed within their time windows;
 - employees must be skilled enough to perform the tasks;
 - ...

$U_{ijk} \in \{0, 1\}$ whether or not \mathcal{E}_i goes from \mathcal{T}_j to \mathcal{T}_k
 $T_j \in \mathbb{N}$ performing time of \mathcal{T}_j

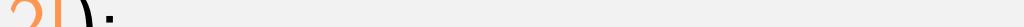
3. Question & explanation in the literature

Questions types

- **Contrastive** (see [1]):
"Why this current decision rather than that other one?"


The text "Why this current decision rather than that other one?" is enclosed in large black brackets. The left bracket covers the phrase "Why this current decision". The right bracket covers the phrase "rather than that other one?". Below the left bracket, the word "fact" is centered. Below the right bracket, the words "foil (often implicit)" are centered.

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	Sequence of independent (question, explanation)	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	Sequence of independent (question, explanation)	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:**
 - explainability in OR, similarly to XAI;
 - tackling real-world problems (WSRP).
 - **Questions:**

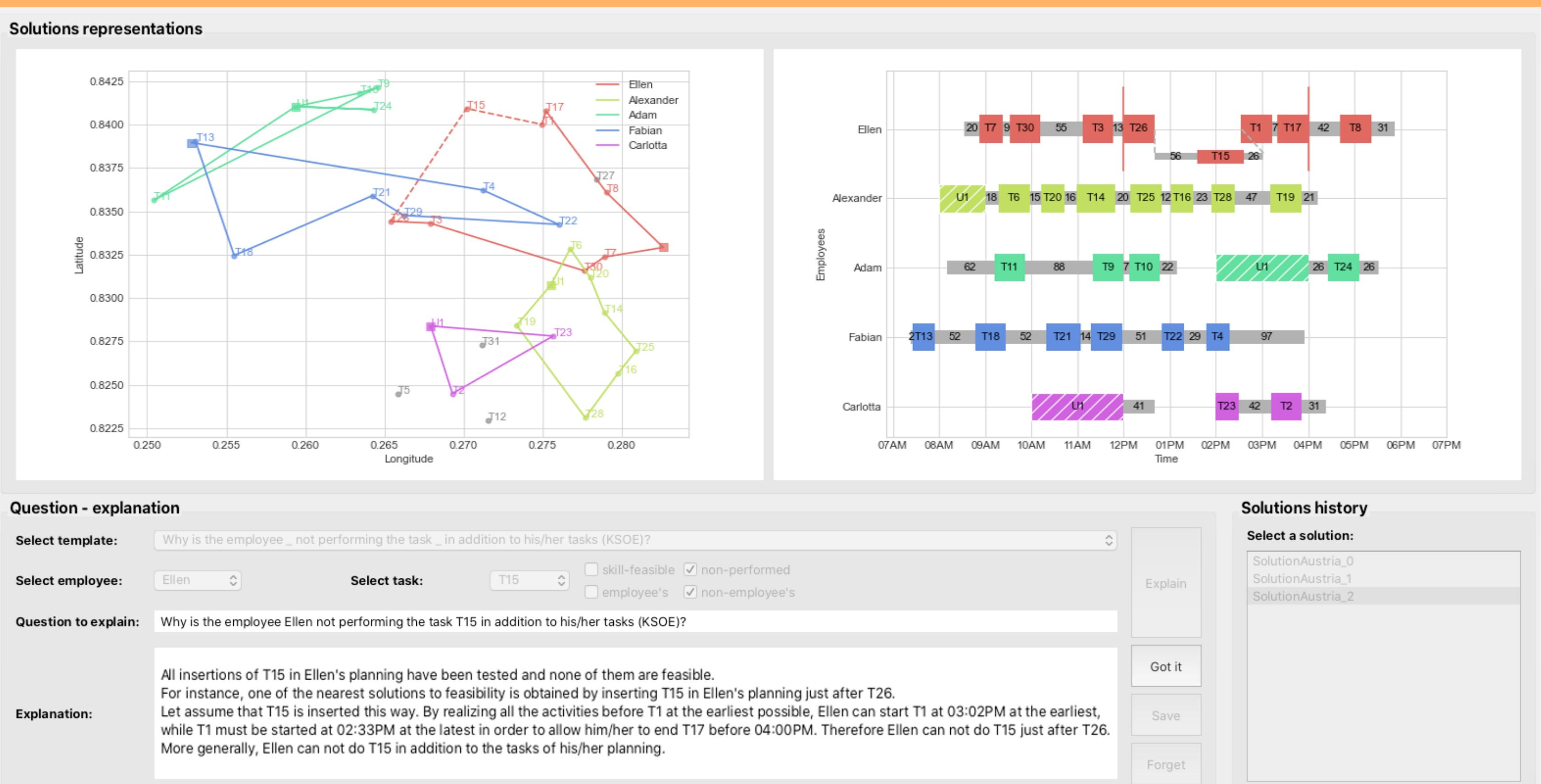
multiple templates of contrastive questions.
 - **Explanations:**
 - not depending on the solving algorithm;
 - include counterfactual explanation reasoning.
 - **User interaction:**
 - dialectical process;
 - solutions and instances spaces exploration;
 - graphic user interface prototype.

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