Mode of Transfer of Control

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Situation

"A semi-autonomous car is currently steering autonomously while the human is occupied by another task.

The human has to take over the control because of an unexpected event (e.g. construction site, accident, …).

The person has to be alerted about the imminent transfer via suitable combination of modalities (e.g. sound, light, text, ...)"

Context-based parameters

Hazard	construction, accident
Urgency	low, medium, high
Current user activity	reading, listening music, watching a film
Cognitive load	low, medium, high
User profile	language, age, gender, hearing difficulty
User preferences	language, text, text size, image, image size, audio, volume, light
Driving condition	normal, night driving

[2]

Output Modalities

Taking into account the set of constraints that we will create using all the variables involved in this problem.

The possible outputs are:

- ➔ **output_light**
- ➔ **output_audio**
- ➔ **output_text**
- ➔ output_image (not implemented)
- ➔ mutations of outputs: **output_light_sound, output_light_text, output_light_sound_text**... [5]

Improving output modality - dynamically

"It has been shown that distracted drivers are capable of taking over control within a time budget of 4 to 8 seconds, depending on the complexity of the situation [3]. If drivers are provided with a longer time budget, they brake less and intervene later [6]. " [5]

Given a time budget of 4 to 8 seconds:

- ➔ trigger Transfer of Control System
- ➔ choose suitable output modalities
- ➔ faster and better situation understanding
- ➔ more time for Transfer of Control
- ➔ “brake less”
- ➔ ...

Scientific background for the approach

Involved scientific topics

- ➔ CSP (Constraint Satisfaction Problems)
- ➔ Multimodality fission
- ➔ ...

Approach chosen

1) Optaplanner - A constraint solver - java [4]
2) Z3 - High performance theorem prover developed at Microsoft Research; Verification, testing, constraint solving, security, etc [3]
3) DLV - Constraint satisfaction problem [1]

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1) Optaplanner - A constraint solver - java [4]
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3) **DLV - Constraint satisfaction problem** [1]

How DLV works?

Rule

$$a\_1 \vee \cdots \vee a\_n \text{ :- } b\_1, \ldots, b\_k, \text{not } b\_k+1, \ldots, \text{not } b\_m .$$

Integrity Constraint

$$\text{:- } b\_1, \ldots, b\_k, \text{not } b\_k+1, \ldots, \text{not } b\_m ?$$

How DLV works?

Rule

a_1 v · · · v a_n :- b_1 , . . . , b_k , not b_k+1 , . . . , not b_m .

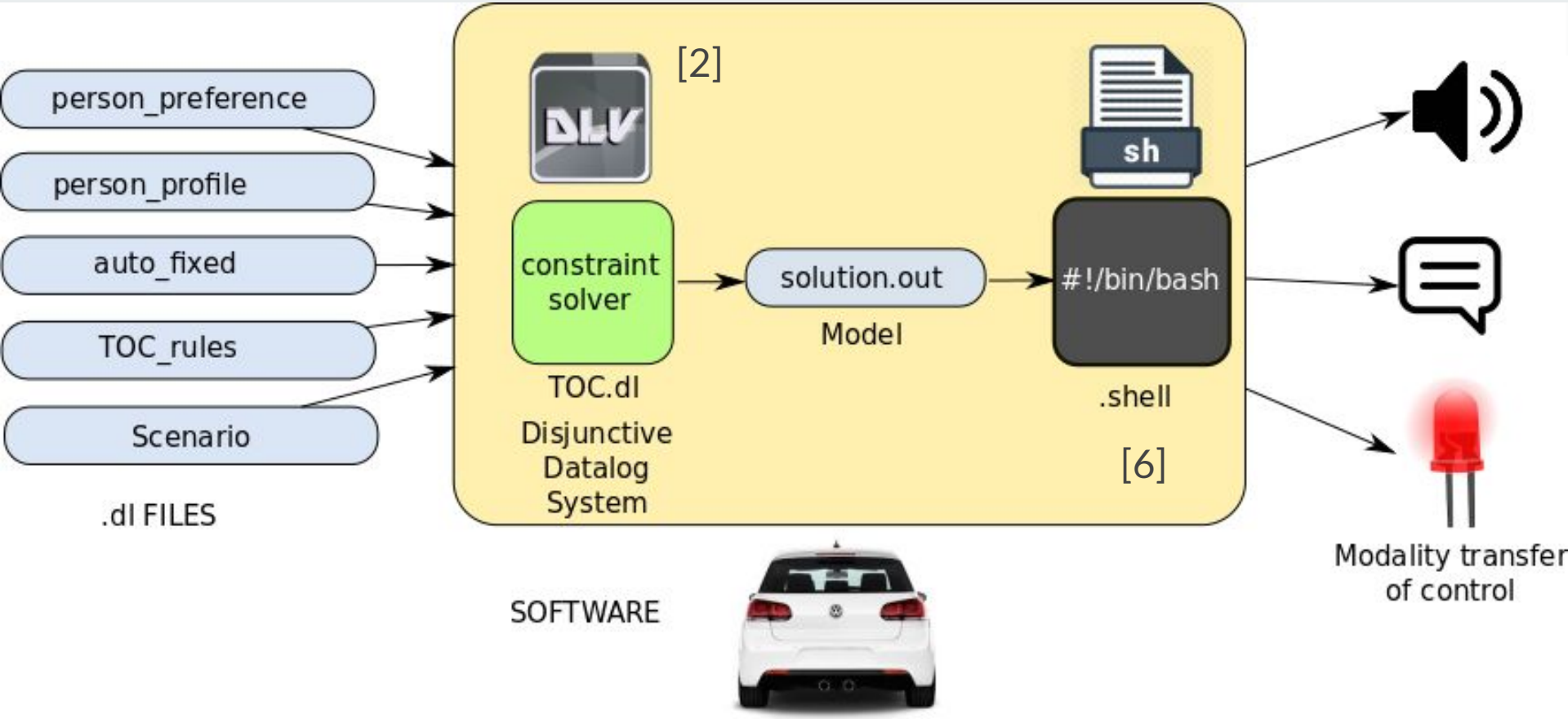
```
urgency(low) v urgency(medium) v urgency(high).
user_cognitive_load(low):- user_current_activity(reading).
```

Integrity Constraint

:- b_1 , . . . , b_k , not b_k+1 , . . . , not b_m ?

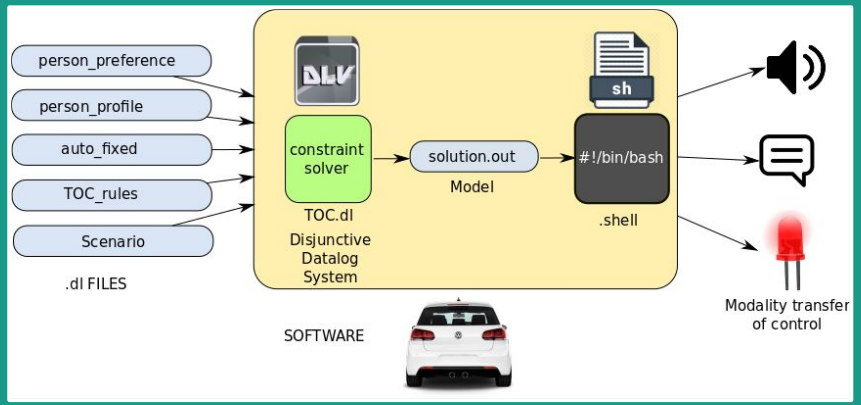
Queries

```
:- preference_text(off), -preference_text(on).
```



Our Model based on DLV

Live demo



{in_control(semi_autonomous_car), transfer_of_control_initiator(semi_autonomous_car), hazard(construction), urgency(low), user_current_activity(reading), driving_condition(normal), preference_language(en), preference_audio(on), preference_volume(low), preference_text(off), preference_text_size(medium), preference_image(on), preference_image_size(medium), preference_light(off), profile_age(elderly), profile_gender(woman), profile_hearing_difficulty(no), profile_level(experienced), profile_language(en)}

Evaluation of the results

There are still more:

- Context parameters to be analyzed. (e.g. preference variables, weather,..., etc.)
- Rules to be analyzed. (e.g. complex situations)
- Advanced methods: machine learning, optimal UI widget realization based on modalities,... etc.

If the human does not take the control of the car in the given time, what should the system do?”

Sources

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[5] Adaptive Probabilistic Fission for Multimodal Systems
https://dl.acm.org/citation.cfm?id=2414575

[6] Investigating the Feasibility of Car-Driver Handover Assistance
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