LTS-Based Analysis of Interactive Systems

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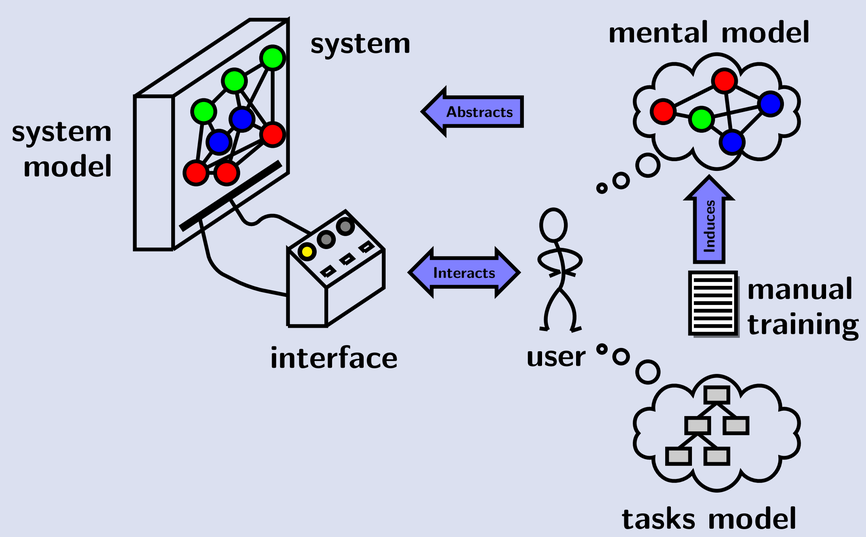
1. Introduction

The aim of the research is to use formal methods to model and reason about interactive systems.



Problems that can be addressed include:

- Check wether a mental model is a good **abstraction** of a given system
- **Generate** a user manual from a given mental model
- **Check** whether user manual allow the user to execute all the user tasks
- Extract part of the system **relevant** to the user regarding a set of user tasks

2. Full-Control Model

Modelling:

- System and mental models as LTSs: $\mathcal{M} = \langle S, \mathcal{L}, s_0, \rightarrow \rangle$
- Action-based user interface: $\mathcal{L}^c$ (commands) $\cup\, \mathcal{L}^o$ (observations) $\cup \{\tau\}$

Problem: Given a system model and an action-based user interface, find the minimal mental model that allows to control the system:

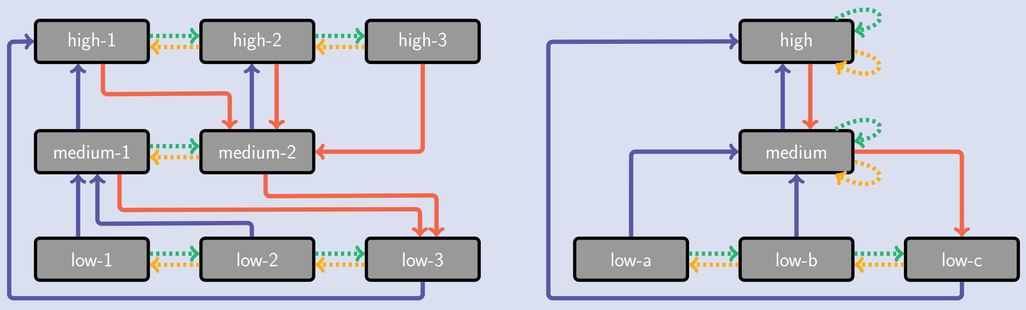
- Commands allowed by mental model are those available on system
- Mental model allows at least observations producible by the system

Approach: Defining an equivalence relation on the system's states, then reducing the system wrt. that equivalence relation. $s \approx_{\text{fc}} t$ iff:

- $\forall s \stackrel{\alpha}{\Longrightarrow} s' : \exists t \stackrel{\alpha}{\Longrightarrow} t' : s' \approx_{\text{fc}} t'$ $\quad (\alpha \in \mathcal{L}^c \text{ a command})$
- $\forall s \stackrel{\beta}{\Longrightarrow} s' : \exists t \stackrel{\beta}{\Longrightarrow} t' \implies s' \approx_{\text{fc}} t'$ $\quad (\beta \in \mathcal{L}^o \text{ an observation})$
- $\forall s \stackrel{\varepsilon}{\Longrightarrow} s' : \exists t \stackrel{\varepsilon}{\Longrightarrow} t' \implies s' \approx_{\text{fc}} t'$ $\quad (\varepsilon \text{ an empty trace})$

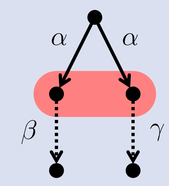
3. Vehicle Transmission System Example

Semi-automatic gearbox (Degani, 2007) **push-up pull-down up down**

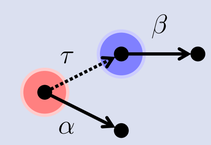


4. Minimization

If the system model is fc-deterministic, i.e. $\forall \sigma : s_0 \stackrel{\sigma}{\Longrightarrow} s \text{ and } s_0 \stackrel{\sigma}{\Longrightarrow} s' \implies s \approx_{\text{fc}} s'$, then $\approx_{\text{fc}}$ gives full-control models.



fc-deterministic



non fc-deterministic

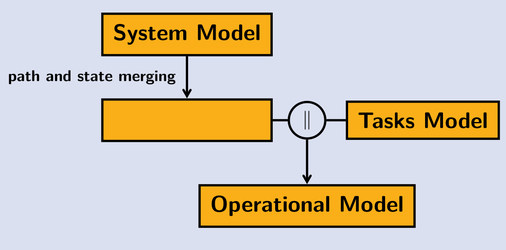
Minimization done with a variant of Paige-Tarjan algorithm.

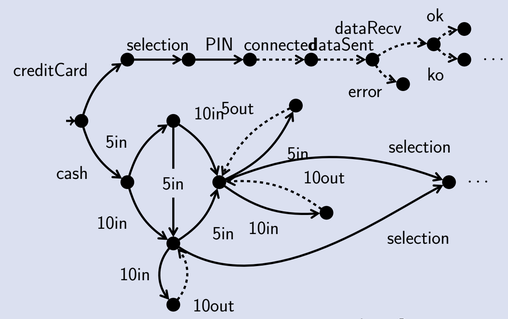
4. Operational Model

Modelling:

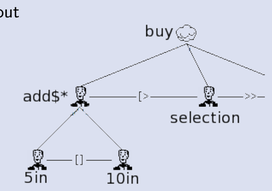
- User's tasks modelleds as a set of LTSs: $\mathcal{T} = \{\mathcal{T}_1, \cdots, \mathcal{T}_k\}$

Problem: Given a system model and tasks model, build an operational model that is a model containing the relevant part of the system regarding the tasks.





- Identifying and merging states of observations path
- Merge states according to tasks hierarchy
- Identifying hub states



5. Conclusion and further work

Contributions:

- Full-control property, equivalence and minimization
- Informal definition of operational model

Further work:

- Mode-preserving model
- Integration information about system's state
- Formal definition of operational model

References

- Sébastien Combéfis, Charles Pecheur. A Bisimulation-Based Approach to the Analysis of Human-Computer Interaction. *EICS2009*, July 2009.
- Sébastien Combéfis. Operational Model: Integrating User Tasks and Environment Information with System Model. *FMIS2009*, November 2009.

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