Timed Automata Modeling of the Personalized Treatment Decisions in metastatic Castration-Resistant Prostate Cancer

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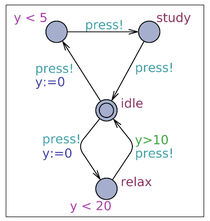
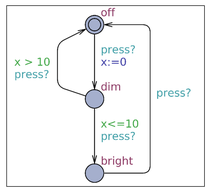
Introduction

The Timed Automata modeling paradigm has emerged from Computer Science as a mature tool for the functional analysis and performance evaluation of timed distributed systems. It has been applied successfully to a large variety of systems, like communication networks, manufacturing plants, and signaling pathways in human stem cells.

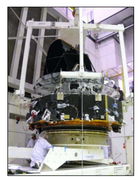
Can Timed Automata be applied also in Medical Decision Making?

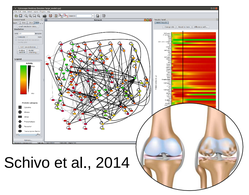


A student



The student's desk lamp


Mikučionis et al., 2011


Schivo et al., 2014

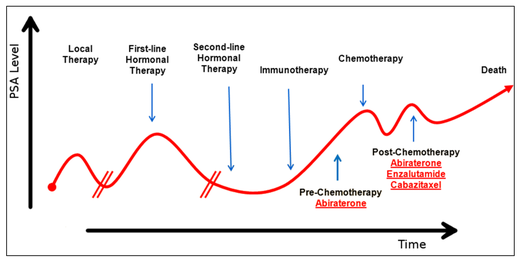
UPPAAL

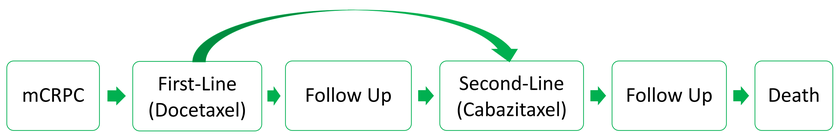
Model and analyze T.A.


Skou et al., 1997

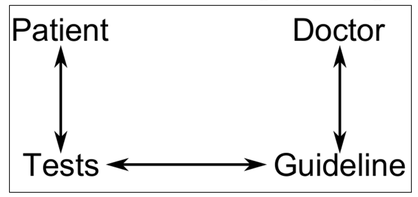
Methods

Case study: mCRPC

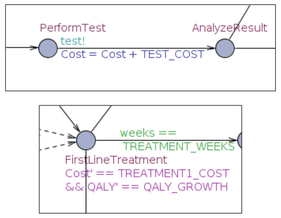




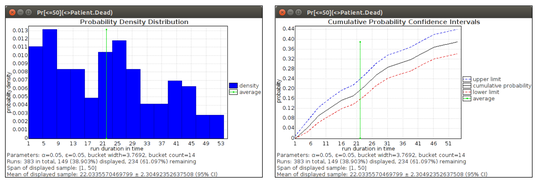
Independent Timed Automata that interact via message passing.



"Time" can represent QALYs and costs.



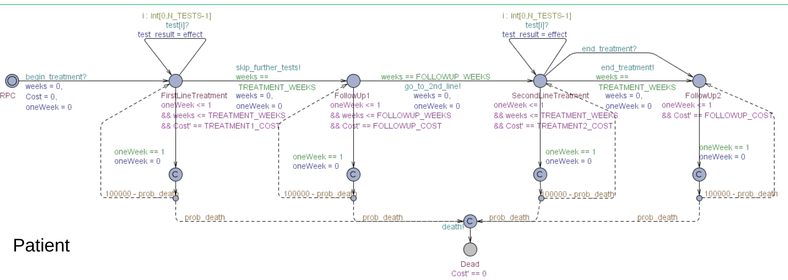
Probability distributions model uncertainty.

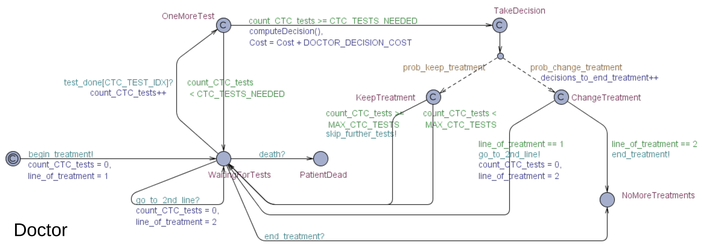


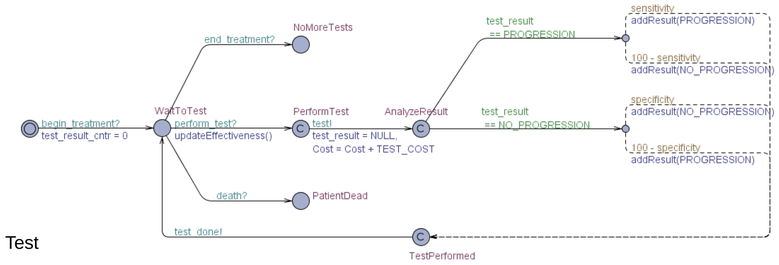
Results

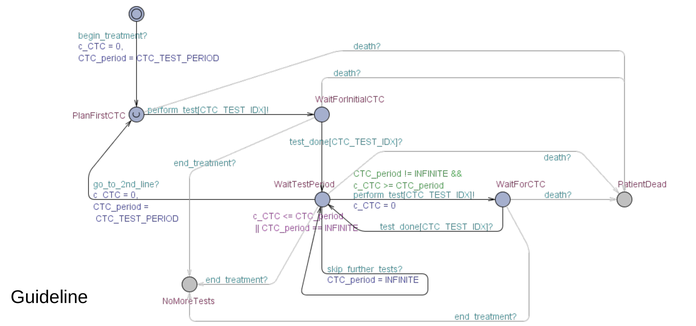
The model is flexible enough to allow us to implement different types of tests, with their own schedule. We modelled two settings (PSA + bone scan vs CTC), comparing them in terms of costs, QoL, treatment effectiveness, diagnostic performance.

In a relatively short time (several days) the models were complete and their performance was assessed with the UPPAAL tool.





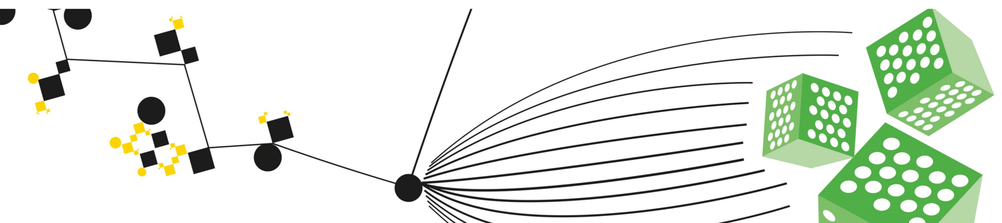




Conclusion

The Timed Automata paradigm can be successfully applied to evaluate the potential benefits of a personalized treatment process of mCRPC. The compositional nature of the resulting model provides a good separation of all relevant components.

This leads to models that are easy to formulate, understand, maintain and update. These models can be validated using the model checking features of Timed Automata, increasing the confidence about the correctness of a model.



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