Environment-aware Surrogate Models for Operation on Weak Mobile Hardware in the Field of Passenger Safety

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High-fidelity simulation models provide insights into complex systems and their behavior. However, the computational costs of such models are often prohibitive for the application in real-world scenarios and for the deployment on weak hardware. Consequently, their application remains elusive for a large number of users and cannot be tailored explicitly to individual needs.

At the same time, knowledge gained from high-fidelity simulation results can be used to create intelligent surrogate models that are much cheaper to compute. Especially, data-driven model reduction techniques offer the possibility to design low-dimensional and low-demanding models that can be used to approximate the high-fidelity models [2]. By identifying a low-dimensional description of the former high-dimensional system, an efficient and low-cost approximation of the model's parametric dependencies can be learned. In this process, the resource consumption of the surrogates can be reduced to such an extent that they can be used to transfer the findings of the high-fidelity models to weak hardware such as smartphones or embedded devices.

In addition, modern smartphone devices can not only serve as a platform for the deployment of surrogate models, but also as a source of sensor feedback to synchronize the virtual models with the real world and improve the model's accuracy, see Fig. 1. An important application scenario for such a system is occupant safety and comfort. Although the posture of the occupant in the vehicle is a key factor in its safety and comfort, it is often neglected in the development of vehicles. Even in cases where posture is taken into account, the information is only used to check whether the vehicle can be controlled in dangerous situations and is monitored with expensive in-vehicle monitoring systems.

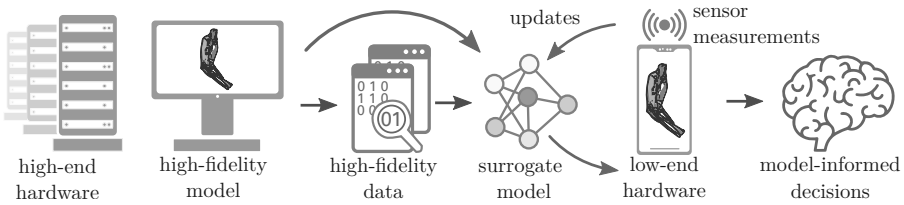

Figure 1: Workflow describing the process of deriving surrogate models for weak hardware based on high-fidelity data.

In contrast to those approaches, we present a smartphone-based passenger safety monitoring system that monitors the occupant's posture and provides feedback to reduce injury risks. Moreover, a surrogate model of the occupant is used to predict his position based on acceleration measurements. It is based on a high-fidelity model of the occupant's body posture and is trained on a large dataset including critical driving scenarios, i.e., scenarios which possibly lead to an accident [1]. The system is evaluated in a driving simulator and shows that the surrogate model can track parts of the occupant's body and infer its acceleration-based position.

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References

[1] Jonas Kneifl, Julian Hay, and Jörg Fehr. Real-time human response prediction using a non-intrusive data-driven model reduction scheme. *IFAC-PapersOnLine*, 55(20):283–288, 2022.

[2] Jonas Kneifl, David Rosin, Oliver Röhrle, and Jörg Fehr. Low-dimensional data-based surrogate model of a continuum-mechanical musculoskeletal system based on non-intrusive model order reduction.