Creating and designing interfaces for human-machine systems demands not only an understanding of the task and its environment, but also an appreciation of the capabilities and cognitive demands of the users. This becomes more and more important because of the growing information density and automation of human-machine systems. Regarding the environment, an important issue is what kind of interface best supports cognitive processes and how can an interface be designed to best match the future user requirements. The work presented here makes a contribution to integrate cognitive aspects of skill- and rule-based activities during human-machine interaction into the development process of human-machine systems.

In early stages of the development process cognitive modeling can be applied to evaluate human-machine interfaces. Using formal cognitive user models to simulate the future user behavior and requirements allows us to analyze the behavior on a detailed level. This helps to detect errors in the interaction design of interfaces and gives indications about the cognitive demands of the future users. But cognitive modeling is seldom used because of the high effort and a lack of tools for the development and analysis of cognitive user models.

In this dissertation the question is raised, in what way cognitive model data can be analyzed and used to evaluate human-machine systems in early design stages. The focus is directed to eye movement data simulated by cognitive user models in ACT-R (atomic components of thought – rational) and human eye movement data. In questions of usability, eye movement studies play an important role and are a reliable way to evaluate visual search and the spatial design of interfaces among other things.

To process both the cognitive model data and the empirical data and to compare the outcomes in an effective and efficient manner the tool SimTrA (Simulation Trace Analyzer) was developed. The tool provides a repertoire of methods to evaluate human-machine interfaces in a formal and computerized way based on cognitive model data. The concept and the implementation of SimTrA and its application in an evaluation study are shown in this dissertation.

The results of the evaluation study show that cognitive user models in general can be applied in early stages of the development process of human-machine interfaces and under certain conditions provide statements comparable with empirical data. The study further indicates that the analysis of simulated eye movement data with SimTrA is possible and supports the evaluation of human-machine systems. Hence SimTrA is a useful tool for cognitive modeling and for prototype evaluation in early design phases of human-machine systems.