An Agent Model for a Human's Functional State and Performance[1]

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For a human functioning in demanding circumstances, the quality of performance may be a critical factor. Examples of such situations are military officers during a mission or air traffic controllers. In cases like these any performed action which is badly chosen, or simply suboptimal can lead to dramatic consequences. To avoid this, it often is of importance to maintain a high performance quality.

However, as is known from literature such as [2], [3] working under high pressure in demanding circumstances often entails negative effects on the human's functional state, which in turn easily may affect performance quality. In literature, cognitive workload is a common term on humans working in demanding circumstances; it is seen as one of many stressors with a negative impact on human performance, like decision making [4], attention [5] and working memory [6]. Examples of other stressors are time pressure, noise and fatigue [4]. In the agent model for the Functional State (FS) of a human, cognitive workload is incorporated as a combination between the task and personal abilities.

A main question taken as a point of departure in this paper is to explore what is required to provide adequate support of a human functioning in demanding circumstances. Given its impact on performance as sketched, having an estimation of the human's functional state (and its implications) at any point in time is a crucial requirement. This requirement is the focus of this paper. To fulfil the requirement, an agent model is proposed that can be used to estimate a human's functional state over time.

The agent model, which was designed in dynamical system style, is based on the cognitive energetic framework [3], which states that effort regulation is based on human recourses and determines human performance in dynamic conditions. Furthermore, the model is based on literature concerning exercise and sports [7]. The idea is that a person's generated power can continue on a *critical power* level without becoming more exhausted. The model takes task demand and situational aspects such as noise levels as input and determines internal factors such as the experienced pressure, exhaustion and motivation, and how they (may) affect task performance. In addition, a human's personality profile is taken as input for the model. The personality profile consists of concepts such as optimal experienced pressure (a person's ideal amount of experienced pressure), low- and high pressure sensitivity (the effect of underload and overload on a person's motivation) and exhaustion sensitivity.

The idea is that such a model can be used in a software environment supporting the human. For example, when it is estimated that the human's functional state may negatively affect task performance, measures can be taken such as alerting the person, or reallocation of a task. Moreover, the model can be used to regulate the task load and/or noise level to keep experienced pressure and exhaustion between certain limits thus avoiding negative effects on performance.

Using Matlab, a large number of simulation experiments under different parameter settings have been performed. These experiments pointed out that the model is able to produce behaviour of different types of personalities, although an extensive empirical validation is left for future work. Moreover, by a mathematical analysis the equilibria of the model have been determined, and a number of expected properties of the model have been verified. For example, these checks pointed out that all variables stayed within their boundaries, and the calculated equilibria are confirmed. In addition, one of the checks

[1] The full version of this paper appeared in [1].

confirmed the specific hypothesis that persons with a high Optimal Experienced Pressure generate more effort and eventually become more exhausted.

The current approach to model functional state combines various aspects of stress, exhaustion and situation awareness. Although a number of other approaches in the literature address these factors separately [7], [9], [10], we are not aware of other attempts to model such a combination in as much detail as this work.

In future work more attention will be paid to the model's *external* validation. The mathematical and automated analyses described above have been successfully performed to guarantee *internal* validity, but this does not guarantee that the model is directly applicable to real humans, and in particular which personality parameter values fit to which person. Therefore, as a next step, validation of the model in laboratory experiments is planned. The idea is to offer a human certain demanding tasks, measure its performance and several physiological data, feed these data into the model, and compare the output of the model with self-reports of the participants (similar to [11]). This will not only provide validation of the model, but also realistic parameter settings for different types of individuals.

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