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A Brain-Inspired Cognitive Support Model for Stress Reduction based on an Adaptive Network Model.

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ABSTRACT

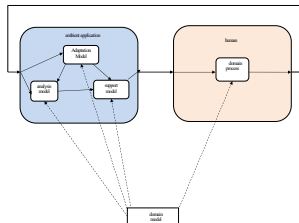
We present practical implementations in the form of client-server software, incorporating the computational model which describes therapy effects for overcoming stress based on quantitative neuropsychological research. The underlying network model simulates the elicitation of an extremely stressful emotion due to a strong stress-inducing event as an external stimulus, followed by a therapy practice simulation leading to a reduction of the stress level. Each simulation is based on user input and preferences, integrating a parameter tuning process; it fits a simulation for a particular user. The client-server architecture software which has been designed and developed completely fulfills this objective. It includes server part with embedded MATLAB interaction and API for client communication.

INTRODUCTION

A cognitive development of a designed model and incorporating cognitive computational models helps individuals, who experience high level of stress, to better understand their stress level and the roles of different therapies to decrease their stress level during a period of following therapy and later on a potential recommendation of changing or continuing therapy based on the performance of the selected therapy.

The structure of the implemented network model including the cognitive states and connections showing the interactions between the states is justified based on the quantitative research available at the moment in the fields of Psychology, Neuroscience, Social Sciences, Computational Science.

Figure below illustrates the resulting ambient application diagram which is broken down in three main components: analysis model, support model and adaptation model.



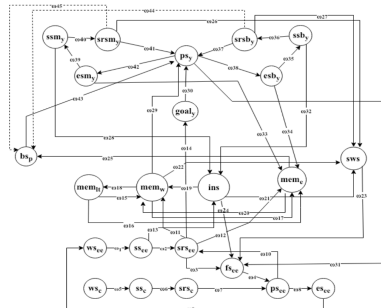
METHODS

Differential equation models are used in many fields such as physics, biology, economics, and engineering. A differential equation model tries to make a connection between a function to its own derivatives [57]. As stated in [57] due to lack of existence of an exact solution for most differential equation models, numerical methods might be used to approximate the solution.

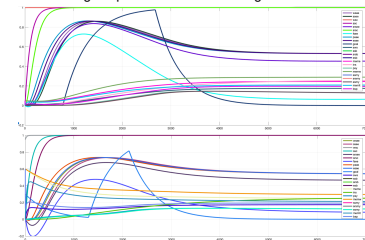
Connection weight ω_{XY} of the connection from a state X to a state Y represents the strength of this connection and the impact value that state X has on state Y . This is often between 0 and 1, but sometimes below 0 for a negative effect, or above 1.

Combination function $c_Y(\dots)$ of a state Y is chosen for each state in order to aggregate the causal impacts of other states on Y .

Speed factor η_Y of a state Y handles the speed of activation change for Y upon impact from X .



In Figure below the simulation outcomes are presented for a person with mindfulness therapy. The upper graph corresponds with a generalized simulation, while on the bottom we see this simulation after the adaptation process for a particular use-case. X-axis indicates the time, Y-axis corresponds to the activation level for a state in the network. The test simulation was made for a user with a higher level of confidence as result of the therapy and with higher persistence in his/her goal.



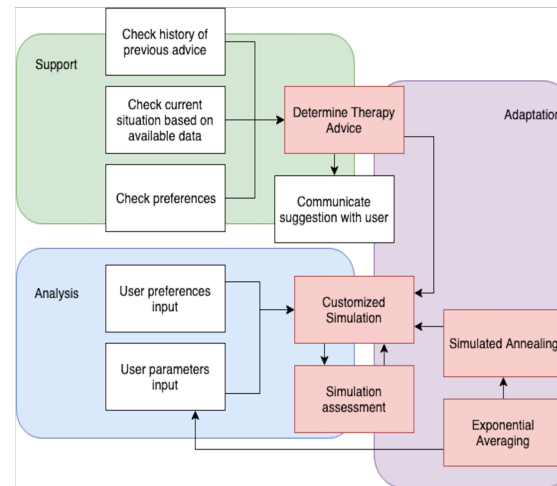
Ambient Model Diagram

The interaction between the sub models helps the user to estimate the amount of stress she/he still perceives has following therapy and a broader overview of the outcome if he/she continues the therapy with the help of simulation results in built-in cognitive computational models and using previous history of doing a therapy by the users.

Red boxes represent important features inside the application while white boxes indicate minor steps. Here the relation between all sub-components is demonstrated using arrows, the direction of arrows shows how different parts influence each other (e.g. parameter tuning with simulated annealing directly affects the customization of simulation for a user). Clear differentiation of the adaptation model is difficult as it also shares common parts with two other models. The process inside the depicted ambient application is as follows: at first a user enters his/her preferences and answers questions regarding the current situation for analysis purposes; next the therapy type is determined based on available data, which is then used for the current user; prior to starting a simulation, a parameter tuning process is applied along with averaging to adapt the simulation; finally, simulation assessment is made after the simulation run to determine its effectiveness.

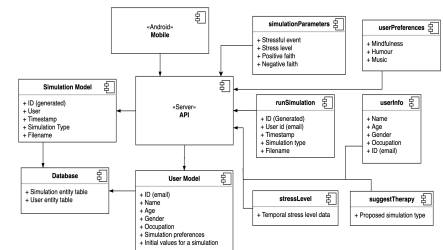
In the analysis sub model, the user inputs such as environmental stress and the internal level of stress are captured by a user input and this information is used as a basis for simulating different cognitive computational models. As has been mentioned earlier, we have considered three different cognitive computational models namely, mindfulness, music, and humor to give the user better understanding of each therapy that he/she is using.

The support sub model is used to clear up the efficiency of a therapy which has been chosen by the user, if the simulation outcome was not in a decreasing trend in the stress level considering the history and preference of a user experience in the support model, the notification of advising to change a therapy is sent to the user.



Server and API

The server part is divided as mentioned, following MVC principles. It includes two models being User and Simulation, and corresponding User and Simulation controllers. Thus, these models are used as data entities and the controllers are implementing all the data manipulations through corresponding repositories, as well as the mapping of the API calls. Another class implemented next to the models and controllers is the simulation service class which contains all the logic regarding various simulation manipulations, such as suggestion of therapy type or running the simulation



CONCLUSIONS

The initial objective of the project was to develop an integrative model incorporating analysis, support and adaptation parts. The client-server architecture software which has been designed and developed completely fulfills this objective. It includes a server part with embedded MATLAB interaction and API for client communication. The final version of the software meets all architecturally significant requirements which were set in the beginning. Prior to the simulation and software development, numerous supportive literature and previous research has been studied extensively, main points of interest in the design process.

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