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BRAIN-COMPUTER INTERFACE-BASED FATIGUE AND ATTENTIVENESS ANALYSIS FOR TASK PRIORITIZATION

HP INC

Brain-Computer Interface-based Fatigue and Attentiveness Analysis for Task Prioritization

Abstract: A task prioritization technique measures a user's mental state using a brain-computer interface, and prioritizes the tasks based on the user'sr mental state to increase efficiency and improve work-life balance.

This disclosure relates to the field of task organization and prioritization.

A technique of task prioritization is disclosed that proactively organizes tasks based on analysis of both the tasks and the measured fatigue and attentiveness of the user who is to perform the tasks.

Time management and task prioritization are two key factors in a person's productivity - not only in a work environment, but also at home. A person may not use his or her full potential if they choose to perform activities that are incompatible with their overall mental state, such as for example their fatigue and attentiveness, at that time. The state of the user can be captured via a brain-computer interface (BCI). Identifying that a person is tired and is losing focus using BCIs is a field of research on its own, having studies in many specific applications such as improving automobile safety, and is not the thrust of this disclosure. Instead, the objective of this disclosure is leveraging this existing field to create a proactive schedule assistant.

According to the present disclosure, a list of tasks and appointments is categorized by their characteristics (level of focus required, amount of stress expected, estimated length of work session and so on). By analyzing the user's current mental state with the assistance of a brain-computer interface, the task that would be most appropriate for that given moment, taking full advantage of their attentiveness and stamina or lack thereof, can be identified. This can improve the productivity and well-being of the user. Slicing time slots for tasks with specific characteristics may also improve the quality of the work.

A BCI, in general terms, is a means to map mental active strategies or involuntary responses to commands or system adaptations. Electroencephalography signals are read from the user through an electrode cap. This data is then sent to a processing device such as a computer which analyzes the brain electromagnetic waves activity captured by the electrodes. The brain wave activity can be used to map the imagination of movements and images to commands, and identify fatigue, attentiveness, distress, surprise, and conditions. Within the context of this article, the BCI would be composed of an electrode cap to acquire the electroencephalography signals and send it to a computing device which processes the data and uses it for prioritizing the user's list of tasks.

The processing of BCI data is commonly performed in three stages: acquisition, processing and classification. The first stage is purely the gathering of signals done by the electrode cap which is then sent to the computing device. The second and third stages utilize one or more processing and classification algorithms used in BCIs. In one example processing chain of acquiring the electroencephalography signals and classifying the current mental state of the user (level of fatigue, attentiveness and distress), the electrode cap acquires and transfers data to the device. The device processes this data using a filtering algorithm (e.g. a Common Spatial Pattern filter). Features are then extracted and used in a classifier (e.g. Naive Bayes). The classifier then determines fatigue, attentiveness and distress. Many other processing and classification algorithms could alternatively and/or additionally be used.

This result then becomes the input for the next step of the disclosed solution: to prioritize the task list to improve productivity, based on the current mental state of the user. In order to have an equivalence between task categorization and mental state so that the two can be linked in the prioritization process, a metric that correlates both is defined. Mental state is analyzed based on fatigue, attentiveness, and distress, while tasks are categorized by risk, stress, focus, and complexity.

For simplicity and clearness, the defined metric in this example limits the user's mental state and the tasks' features to three levels: low, medium, and high. However, these are arbitrary and other measures can be used.

Take for instance the following example. Assume that tasks to be performed are categorized as follows:

Task	**Risk**	**Stress**	**Focus**	**Complexity**
Answering email with questions about a project	Low	Low	Low	Low
Reviewing user stories for the day	Low	Low	Medium	Low
Working on a story about adding a new button	Medium	Low	Medium	Medium
Working on a presentation for a conference	Medium	Medium	High	Medium
Review and suggest performance improvements on a machine learning algorithm	High	High	High	High

Further, assume that the current mental state of the user at a given moment is determined to be as follows:

Fatigue	**Attentiveness**	**Distress**
Medium	High	Medium

After defining the measures, a method for calculating the priority of each task is applied. An example formula for calculating priority based on a pre-determined heuristic is used here to illustrate the principles of the disclosed technique.

Pre-determined heuristic

In a pre-determined heuristic implementation, a mathematical formula defines the relationship between the user's current mental state and the tasks' characteristics, in order to calculate the priority of each item. The following expression is one possible design for this:

$$p = (\alpha_1 f + \beta_1 a + \gamma_1 d)R + (\alpha_2 f + \beta_2 a + \gamma_2 d)S + (\alpha_3 f + \beta_3 a + \gamma_3 d)F + (\alpha_4 f + \beta_4 a + \gamma_4 d)D$$

The variable p is the calculated priority for each task; lowercase a, f and d are, respectively, attentiveness, fatigue and distress of the user; and uppercase R, S, F and D are, respectively, risk, stress, focus and complexity of each task. The Greek letters α, β and γ are percentage weighting constants that will describe how meaningful each user characteristic is for each task characteristic. For example, attentiveness is important when talking about a risky activity. Thus, it should be weighted by β_1 with a high positive percentage value. On the other hand, the more fatigued a user is, the more dangerous it becomes to execute a risky task. Because of this, increasing fatigue should decrease the task's priority, and so α1 should be a negative weighting value.

Using the tasks and mental state as presented heretofore, low, medium and high mental states are translated to scores 1, 3 and 5 respectively (again, for example purposes only). Furthermore, the following weights were chosen arbitrarily for the sake of the example.

Weights	Risk	Stress	Focus	Complexity
Fatigue	-45%	-40%	-40%	-20%
Attentiveness	45%	20%	50%	40%
Distress	-10%	-40%	-10%	-40%

The resulting prioritization table is shown below. It can be observed how, given the user's current mental state, the priority of very simple tasks and very complex tasks is lower, whereas the priority of medium difficulty tasks is higher.

Task	Risk	Stress	Focus	Complexity	Calculated Priority
Answering email with questions about a project	1	1	1	1	0.4
Reviewing user stories for the day	1	1	3	1	2.4
Working on a story about adding a new button	3	1	3	3	4
Working on a presentation for a conference	3	3	5	3	3.2
Review and suggest performance improvements on a machine learning algorithm	5	5	5	5	2

This implementation requires no input from the user, as the heuristic is pre-determined.

Supervised machine learning

In other examples, a supervised machine learning algorithm can be employed if desired to give the user a more granular control over the prioritization mechanism. In a supervised machine learning scenario, the user is prompted with different situations and provides feedback on how they believe they can be the most productive. The system has a standardized learning session which displays different mental states and a list of possible tasks, requiring the user to select which task they would rather do when feeling that particular mental state.

Sequentially, the machine learning algorithm would classify and determine the priority of tasks based on what it has learned in the learning session. The system can also request feedback from the user after prioritizing tasks so that it could continue to improve its learning.

The disclosed technique advantageously makes improved judgments of which tasks can be more easily completed and result in less stress for the user based on their mental state at a particular time, which can increase the quality of the work they produce and reduce their mental fatigue. The technique may be deployed in personal assistants of mobile phones, tablets, or computers to easily record tasks, prioritize the task list, and suggest to the user what to do at a particular time.

In a simple interaction with an assistant, a user could say “remind me to finish writing this email” and “remind me to walk my dog”. Prior digital assistants would only record these two tasks, whereas an assistant using the disclosed prioritization technique can also re-order the list and suggest which item best fits each given time.

As such, the disclosed technique can increase a person’s efficiency and help optimize their work-life balance.

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