Tenth International Conference on Managing Fatigue: Abstract for Review

A method for external validation of fatigue monitoring technologies

Daniel R. Bongers, SmartCap Technologies Pty Ltd, daniel.bongers@smartcaptech.com

Problem

Fatigue monitoring technologies have enjoyed moderate adoption over the past decade, predominately in the mining sector. While user acceptance remains the principal hurdle for businesses and vendors alike, the primary product-centric problem remains to be external validation.

Internal validation studies, while rarely independent, allow for secondary, comparative measures in a controlled environment. No such model for standard validation exists for use in field, especially if external validation is to be done on a large scale.

This paper proposes a data-driven, technology-independent approach that can be used for external validation without the need for secondary measures.

Method

The approach taken was to establish a list of verifiable facts which would allow context to be applied to observations in data. An example for an EEG-based technology would be that the only input to the product's algorithm was spectral EEG information. Once verified, such a fact would establish that time of day, for example, was not included as an input to add artificial circadian patterns to the dataset.

In following from a platform of facts, a number of testable hypotheses are made, each based in established, peer-reviewed science. For example, should the technology employ an audible and/or visual stimulus, it would be reasonable to hypothesize that the technology should show a statistically significant increase in alertness (or decrease in fatigue metric) in the near vicinity following the stimulus.

For such an approach to prove compelling, it is necessary to include complex hypotheses that demonstrate a clear intent to test the technology, whilst still providing visual representations to communicate results to a non-scientific audience.

SmartCap is an EEG-based technology used in the mining and on-road logistics segments. This method was applied to SmartCap data collected from mining operations in the United States, Australia and Chile. In total, 2.4 million hours of data was analysed, covering a total of 3,824 individuals.

Results

In total, 5 tests were applied, in order from simple to complex.

Stimulus-based tests were applied on an individual and aggregated basis, as were tests to identify the evidence of circadian rhythms; all other tests were applied on an aggregated basis.

All tests applied showed significance ($p < 0.01$) in support of the technology's validity. On an individual level, the analysis revealed a statistically-significant consistency between independent-sample, spliced datasets, illustrating the ability to show consistency between individualised circadian patterns. In addition, post stimulus alertness as well as significant, strong correlation was shown between lulls in alertness and detection of impairment on an hourly basis across the 24-hour day.

Discussion

These results provide a compelling case for the technology tested. More importantly, the method applied provides a platform for external validation of any deployed technology, regardless of the underlying science. Furthermore, the nature of the testing lends itself to independent application, such that prospective users may seek independent assessment as part of the technology comparison process.

The greatest limitation to this approach is practicality. Certain foundational facts must be established, and in many cases this would require cooperation and disclosure on the part of the technology vendor. That said, independent assessment of such elements would only be needed once, upon which any number of datasets could be subjected to validation.

Another significant hurdle to this approach, should such validations become public domain, is the need to find agreement with an independent expert. It has been the author's experience that concerns of conflict arise, which may impact the expert's perceived "trusted advisor" status within the academic community.

Finally, whilst the core approach is technology-agnostic, some technologies (e.g. camera-based) will need to apply slightly different tests, based on the relevant observations able to be made.

Summary

This paper presents a defendable method to perform external validation on a fatigue monitoring technology. Using a dataset of 2.4 million hours of use, tests are performed which show statistically significant support for the technology claims. While limitations exist, and commercial concerns may prevent some technologies from subscribing to such testing, the methods presented offer research institutions and prospective business and individual users the opportunity to make more informed choices when adopting fatigue monitoring tools.