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GEOMETRIC BROWNIAN MOTION (GBM) RANDOM PROCESS MODEL APPEARS TO BE AN EXCELLENT CHOICE FOR MODELING REALIZATIONS OF PERCLOS SIGNALS

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Introduction: The PERCLOS (PERcentage CLOSure) for one eye and a given time window of duration T seconds (typically 20) is the total time where the eye is closed more than, say, 80% with respect to some reference maximum opening, divided by the window length. Since PERCLOS is recognized as an important indicator of drowsiness, several drowsiness monitoring systems, e.g. for drivers, use it as their unique or primary parameter. All these systems compute PERCLOS "now" based upon the ("past") data in the window, so that an alarm may come too late to prevent an accident. It would thus be useful to predict future values of PERCLOS based upon this past data. Prediction implies having a model of the evolution of a "PERCLOS signal". Given that the motion of the eyelids – governed by complex physiological phenomena – has a significant random part, one must treat each PERCLOS signal as a specific realization of some (underlying) random process (RP). Predicting future values of PERCLOS then requires having a proper RP model for the time evolution of PERCLOS. Here, we present such a model.
Materials and methods: Using a glasses-based system imaging one eye and developed in our group, we obtained PERCLOS signals from 17 healthy subjects who performed psychomotor vigilance tasks (PVTs) at 3 different states of sleep deprivation. Each of these 17x3 = 51 signals consists of 110 samples spaced by 5 seconds.
We investigated several RP models to model these realizations, and we found that the Geometric Brownian Motion (GBM) RP model constitutes an excellent choice.
RP X(t) is said to be GBM if it satisfies the stochastic differential equation $dX(t)/X(t) = \mu dt+\sigma dW(t)$,
where μ and σ are positive constants and W(t) is a Wiener (random) process also called Brownian Motion.
For each realization, we determined whether or not GBM was a good model choice by applying the conventionally applied procedure of verifying that the logarithms of the ratios of successive values are normally distributed and uncorrelated in time.
Results: We found out that each of the above 51 PERCLOS signals passed the above pair of statistical model selection tests, so that GBM is a good model choice for each of these 51 signals.
Conclusions: We found that GBM is a good choice of model for all of our 51 PERCLOS signals. In general, for any signal that can be modelled by a GBM, there are methods (mainly found in finances) for statistically and usefully predicting its future values. Therefore, for all 51 signals considered, one could do such predictions.
While we showed that each of the 51 signals above can be modeled by a GBM, this is not a proof that all PERCLOS signals are necessarily produced by a GBM. However, our finding is a strong motivation for future research to examine whether there is a fundamental physiological and/or mathematical reason why all PERCLOS signals should be GBM.
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PREDICTION OF LEVEL OF DROWSINESS USING AN ADAPTIVE GEOMETRIC BROWNIAN MOTION MODEL, WITH APPLICATION TO DROWSY DRIVING ACCIDENT PREVENTION

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Introduction: Existing drowsiness monitoring systems appear to compute a level of drowsiness (LoD) at the present time based on data up to it. An LoD so produced is not the value of the LoD now. Even if it were, an alert based on it would generally come too late. It is thus paramount that future systems predict the value of the LoD some time-interval ahead in the future. Here, we show that one can produce excellent predictions a chosen number of seconds ahead.
Materials and methods: We recently showed that Geometric Brownian Motion (GBM) excellently models LoD signals. Here, for each LoD signal considered, we use two prediction approaches: we compute a GBM model either once for the whole signal, or repeatedly for the sub-signal corresponding to each position of a fixed-length, sliding window extending up to the present. Obviously, this requires that the corresponding (sub-)signal be GBM, i.e. that the logarithms of the ratios of successive values be normally distributed and independent.
Results: We used an eyeglass-based photooculographic system developed in our group that produces validated LoD signals. We had 17 healthy subjects perform PVTs at 3 different states of sleep deprivation, and got 51 signals, each with 110 samples produced every 5 sec. Each window is 55 sample long and stepped by 1 sample. Predictions are made 4 samples (20 seconds) ahead. For comparison, it takes a 60-mph truck 6 seconds to leave its lane. Applying the above normality and independence conditions, we established that all 51 signals and 17 sub-signals – each in one randomly selected window for each of the 17 subjects – were all GBM. In operation, one would likely assume that all (sub-)signals are GBM (as established in studies such as this one). For each of the 51 signals, we proceeded as follows.
For the fixed model, we computed its parameters once using the full signal, and used them to compute directly all predicted values 4 samples ahead. For the adaptive model, we computed its parameters for each position of the window and used them to compute the (single) predicted value 4 samples ahead. In each case, we thus produced a prediction signal time aligned with the true signal.
We checked the prediction quality visually by comparing the predicted values and their 95% confidence levels to the known, true values: for both approaches, the predictions were all remarkably close to the truth. We did not notice significant difference between the fixed and adaptive approaches; however, the fixed one uses twice as many samples to compute the model and is not usable operationally.
Conclusions: The very preliminary work reported here indicates that the GBM appears useful for predicting future LoD values, including adaptively using a moving estimation window. The present work uses very short signals (110 samples), so that one should expect even better results in real operation, where the signals processed would be much longer, allowing for finer predictions.
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Other

TOTAL SLEEP TIME IN A BRAZILIAN BIRTH COHORT: PRELIMINARY

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Introduction: The total sleep time (TTS) is a major factor studied in medicine, being associated with physiological and metabolic disorders, such as appetite regulation, immunity, hormonal function and cardiovascular system. Nowadays, the technological evolution is promoting a reduction in the sleep time of humans, especially in modern societies. Birth cohort studies bring the possibility of conducting research with a temporal window that begins at birth and extends to the present, representing an opportunity that may help us to understand the mechanisms that lead to sleep deprivation. In these preliminary results, we evaluate the total sleep time in a young adult population and the relation of total sleep time with sleep quality, sleepiness, obesity, hypertension and Willis-Ekbon Disease.
Methods: The study population came from a larger study called COBRAS (COorte BRASsileiras) and started in the 1970s with the initial objective of studying the development of live births in the region of Ribeirão Preto, Sao Paulo, Brazil. Firstly, a cross-sectional study of this population was carried out to evaluate the total sleep time, sleep quality (Pittsburgh Sleep Quality Index – PSQi), sleepiness (Epworth scale), the presence of Willis-Ekbon Disease and anthropometric data such as weight, height, BMI and blood pressure. Total sleep time was assessed using a questionnaire.
Results: Out of more than 5000 individuals, 1560 were interviewed so far. The mean age and standard deviation (SD) were 33 +/- 7.6 years. The total sleep time was (mean ± SD) 6.7 +/– 1.5 hours. Women sleep significantly