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Opinion: Setting the stroboscopic visibility threshold

The European Commission's regulation of light sources under the Ecodesign Directive is establishing mandatory requirements on the stroboscopic effect, using the stroboscopic visibility measure (SVM). As we have invested considerable effort over the past years developing and validating the SVM, results of which can be found in several journal and conference publications, I am pleased to see that the measure is recognized and approved by the law makers.

The stroboscopic effect is not directly observable but requires that a temporally modulated light illuminate a moving object. The resulting perception of motion, which under daylight would be motion blur, is perturbed, unsmooth or jerky. The visibility of this spatio-temporal effect is not only a function of temporal modulation of the luminous output but also of the features of the moving object it illuminates, such as its speed and contrast against the background.

SVM was developed using a high-contrast fast-moving stimulus representing the realistic worst-case conditions in a general illumination application. In a series of perception experiments, an absolute sensory threshold was measured at the point where the observer can detect the stroboscopic effect 50% of the time. Consequently, SVM = 1.0 is defined by a light waveform at such modulation depth, frequency and wave shape for which the stroboscopic effect can be detected by an average observer with the probability of 0.5.

The threshold is based on the standard definition introduced by Fechner in the 1860s, commonly used across the vision and lighting research fields, e.g. in the colour-matching functions. It does not mean that an observer will have a clear idea that she can see the stroboscopic effect 50% of the time and not the other 50%. Instead, she is uncertain and decides to respond with 'I see it' 50% of the time, the chance level. Further to the long-standing definition, most experimental methods that are in use for building visibility models will yield the 50% threshold. If an observer is given a dial to turn to make the modulation larger or smaller and asked to find the limit between *not visible* and *visible*, she will give the 50% threshold.

SVM was designed to equal 1 at visibility threshold; EU regulation, however, proposes instead a stricter limit of 0.4. This precautionary approach is probably based on the argument that exposure to temporally modulated light can have adverse health effects on people. But SVM predicts the stroboscopic effect *visibility*, and research is still needed to link it to health-related effects. In a recent study of long-term exposure to stroboscopic effect, we demonstrated that the higher temporal modulation light (SVM = 1.34 vs. SVM = 0.47) did not significantly increase the occurrence of health and wellbeing parameters (like headaches). My concern is that the 0.4 limit has not been validated. I am pleased to see our measure being used in the EU regulation but, simultaneously, I am surprised that the limit is not SVM $\leq$ 1, as per design.

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