Probe of the quintessence of surprise

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We ignore some sudden noises, while others make us take action. We turn our eyes to look at some moving things -- but not all. Why? A new theory and experimental evidence suggests a novel mathematical explanation of how brains measure "surprise" in a data stream--a theory that an NSF funded study will explore.

Information theorists Pierre Baldi of UC Irvine and Laurent Itti of the University of Southern California are joining with electrophysiologist Douglas Muñoz of Queens University, Canada on the $600,000 study.

Itti, an assistant professor of computer science at USC's Viterbi School of Engineering who is principal investigator on the project, notes that "rapid reaction to change is often a matter of life or death for animals. A faint rustle or puff of dust can signal the presence of food to seek, or a predator to flee. But what marks some changes as demanding attention?"

The new computational theory of surprise was conceived by Baldi, who is director of the Institute for Genomics and Informatics (IGB) [www.igb.uci.edu] at UCI in 1999, first published in 2002, and has been developed experimentally with Itti subsequently. Early laboratory experiments have shown the Baldi-Itti model outperforms previous theories in predicting human responses to sudden unusual stimuli.

The NSF award will put the theory to intensive testing. "We believe this approach has potential for profoundly changing our current notions of how 'important' or 'surprising' information is understood," said Baldi.

"This is a very exciting project," said Kenneth Whang, program director at NSF's Computer and Information Science & Engineering (CISE) directorate. "The researchers have developed an elegant theory from first principles that has a lot of explanatory potential."

Baldi and Itti will present the outlines of their mathematical understanding of surprise -- along with their empirical studies on human subjects that support their theory -- on Wednesday, December 7 at the Neural Information Processing Systems (NIPS) Conference in Vancouver, British Columbia.

The new NSF project combines forces of Baldi's computational and theory labs with the modeling and psychophysics lab of USC's Laurent Itti, and expands the research to include neurophysiological studies of brain mechanisms in Muñoz electrophysiology lab at Queen's University (Canada). Both experiments and modeling will be combined in the project to develop a new understanding of how the brain codes for novelty and importance.

"Our new model has implications not only for neuroscience, but for many fields, including information theory, psychology and engineering," said Muñoz, who has wide experience in the field.

"This is exactly the kind of collaboration we were hoping to encourage," said Whang, who coordinates the Collaborative Research in Computational Neuroscience (CRCNS) program involving five NSF directorates and nine NIH institutes.

Source: University of Southern California

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