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News

Robotic roach creates order from chaos

Chaos theory eases the path of autonomous robots.

Zeeya Merali

Chaotic cockroaches may sound like the stuff of nightmares, but they could be key to making robots more adaptable. The application of chaos theory to the mobility of robotic insects may also help biologists to understand animal motion and could have medical applications.

A touch of chaos could help robots get around.

P. Manoonpong et al.

Autonomous robots designed to venture into hostile environments where humans cannot safely or easily tread must be able to adapt their motion to their surroundings — the rocky terrain of another planet, or a war zone, for instance. But at the moment adding new behavioural patterns, such as a new walking gait, to a robot's repertoire is cumbersome, says Marc Timme, a physicist at the Bernstein Center for Computational Neuroscience in Göttingen, Germany. "Each new gait requires the addition of new hardware for a new controller to govern that behaviour," explains Timme. Any decision-making process then requires all controllers to co-ordinate their information, making the robot less efficient and versatile.

By contrast, in nature even primitive creatures such as cockroaches can control complicated motion quickly and with ease, despite having relatively few neurons, says Timme. Inspired by the cockroach's abilities, Timme and his colleagues have built a six-legged robot, named AMOS (Advanced MObility Sensor driven), with 18 motors controlling leg movement and 18 sensors providing information about heat, light and contact with the ground. The team's aim was to fit AMOS with a single controlling processor that would allow it to adjust its walking pattern quickly and automatically in response to changes in its environment (see *Nature*'s **video**).

Chaos control

To do so, the team turned to chaos theory, which describes how small changes in the input to a system can create a huge range of markedly different outputs — some of which are stable, others of which are not. The team's new processor, which is built from a circuit of just two 'neurons', uses a chaotic algorithm to generate and sort through possible output patterns on the basis of AMOS's sensor-input data. The processor quickly rejects unstable options before settling on a stable walking pattern. "Chaos is not usually thought to be a good thing, but we

have turned it upside down, using it constructively to stabilize motion," says Timme.

Thanks to this chaos-control technique, AMOS can negotiate rough terrain, run away from predators (see **video**) and choose an energy-saving gait when walking uphill (video **here**). AMOS also uses chaos directly when it loses its footing (see **video**). "When one of its feet loses contact with the ground, chaotic behaviour takes over and it goes crazy", trying out random combinations of gaits until it scrambles out, explains Timme. The team has published its results online today in *Nature Physics*[1].

The idea can also be easily implemented in other existing systems. "One can immediately use the same set-up for the single central pattern generator and its control in other robots," says Timme.

In the mind

"The team has successfully handled multiple inputs from many sensors to generate extremely complex stable behaviour," says Eckehard Schöll, an expert on chaos control at the Technical University of Berlin.

The application of the technique to control autonomous robots by a simple neural circuit demonstrates that it could have many cross-disciplinary uses, including stabilizing harmful neuronal activity in people with epilepsy, Parkinson's disease or migraines, says Schöll. He and his colleagues are currently investigating excitation waves that are triggered in the brain prior to the onset of migraine[2]. "It's our hypothesis that in healthy individuals there are feedback loops in the brain that suppress such waves," says Schöll. If so, it may be possible to use chaos control to suppress the waves by varying the intensity of light that patients are exposed to in a particular way.

Ansgar Büschges, a zoologist at the University of Cologne in Germany, is studying whether chaotic control could also be at play in real animals when they walk.[3] "One of the most prominent questions in neuroscience is how animals can do many things at once — for humans, walking, talking and carrying things," he says. The cockroach robot provides a specific model that biologists can test. "We could now use neuronal imaging to see if a similar pattern of activity is seen in moving animals," says Büschges. ■

References

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Robot creates (?) order from chaosâ€¦? #9331

The notion of chaos, as it is assumed and used in nonlinear dynamics, synthesizes the Greek root khaos, which refers to an originating primordial structure.

The notion of chaos signalizes and localizes the existence of order/structure in the aleatorial, which, in turn, is situated at the level of the systemic effects that depend upon the formative conditions of the systems. That order is incorporated in the systemic adaptive "kits".

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