FROM MOTION TO DATA TO KNOWLEDGE

Customer Case Study

Spider Web Design and Silk Analysis using ProAnalyst®

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Abstract

Biological researchers at the University of Akron in Ohio are conducting evolutionary studies on spiders and their silk. The team uses ProAnalyst® motion analysis software from Xcitex to analyze web construction techniques and materials for a number of spider species.

Did you ever wonder what else those itsy bitsy spiders are doing? At the University of Akron, postdoctoral scholar Andrew Sensenig, Ph. D. and Associate Professor of Biology Todd Blackledge, Ph.D., assisted by biology undergraduates Sean Kelly and Kimberly Lorenz, are using Xcitex's ProAnalyst motion analysis software to study spiders and their silk.

Funded by the National Science Foundation, the study has several objectives. The team hopes to gain a better understanding of the biomechanics of silk and webs from species to species, silk characteristics during realistic insect captures, which species of spiders produce the best silk, and the process of artificially reproducing a product as strong as silk in industrial applications.

The study raises many evolutionary queries relating to web and silk design. The team seeks to provide answers to questions such as: how does high-quality silk evolve multiple times during the evolution of a certain species? Why do web design patterns vary among species? How do wind conditions and other environmental factors affect webs?

ProAnalyst software is ideal for this type of biological research because of its ability to automatically track natural features without the use of optical markers. The movements of the spiders and their web construction techniques are easily analyzed with no adverse impact to these fragile subjects or their natural environment.

Although they have used over a hundred species in their research, the University of Akron researchers have been working primarily with Orb Weavers because these spiders consistently create planar (flat) web designs even if they are in an unnatural environment or under duress. The flat web characteristics enable the team to easily pinpoint the "silk junctions" of the spider web, and allow ProAnalyst to track the movement of over 70 unique points on the web simultaneously.

ProAnalyst's 2-D calibration simplifies the challenging process of tracking a large number of points. Dr. Sensenig commented on this feature, saying that Xcitex's software was ultimately chosen for its "great perspective calibration abilities," perfect for videos filmed with non-perpendicular camera angles. The team also commended the Xcitex staff for their technical assistance in the plotting and tracking of many points.

As described in their article, *Behavioural and biomaterial coevolution in spider orb webs*, Sensenig and his team replicated the weight of a spider's prey and web deformation under pressure by shooting at the web with a small cannon loaded with balsa wood projectiles weighing 300 to 500 mg at speeds of 1 - 2 meters per second. By using different velocities, the team measures the tensile strength of the webs to better understand why natural silk is so strong – five times stronger than steel. Test results showed that the webs of larger spiders were capable of absorbing more energy than small spiders' webs. This extrapolates to prey weights of up to 3000 mg, or three times that of the spider's body. The researchers use a Fastec TroubleShooter high-speed camera to capture video with a frame rate of 500 fps. The duration of a typical recording is about three seconds. The kinetic and potential energy change of the projectiles was determined by tracking speed and trajectories with ProAnalyst's 2-D tracking. The team selected and autotracked several points on each web to track web motion after impact, and then calculated the displacement of the web as the projectile struck.

The research team attributes the strength and resilience of different webs to the interaction of web components when arresting the spider's prey. In these situations, different types of silk behave very differently mechanically and may serve different roles in prey capture, particularly with relatively large and small prey sizes. In this study, a total of 295 impact events were analyzed for 50 webs.

ProAnalyst was used to digitize two edges of the projectiles. Perspective calibration with a planar grid of 3 cm squares allowed the camera to be at an angle to the web. The motion of the projectile was almost entirely on this grid. Data was filtered using a Butterworth 20 Hz low pass filter. Speed, velocity, and position data for the prey edges were calculated in ProAnalyst before being exported to an Excel spreadsheet. Other options for ProAnalyst report generation include MATLAB, PowerPoint, and HTML web pages.

For more details about the University of Akron study, visit: http://gozips.uakron.edu/~tab27/index.htm.

For more information about ProAnalyst and other Xcitex products, visit us at www.Xcitex.com.

Technology Profile

Xcitex ProAnalyst® motion analysis software
Fastec TroubleShooter high-speed video camera

For further information on Xcitex products, visit www.xcitex.com or send an email to info@xcitex.com.

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