

High-speed cameras capture foot motion

Today's sports shoe designers may use computer-aided design (CAD) systems to model their shoes, but only by assessing how the shoes will perform can manufacturers be assured they have optimized the designs. By performing both kinematic and kinetic studies using high-speed motion analysis systems, a well-known German manufacturer has recently installed a motion capture laboratory at its facility in Herzogenaurach, Germany (see figure).

Because the runner's foot is not likely to strike the ground on the same spot, a wide area of view is required. Furthermore, the system must be placed a considerable distance from the runner, which requires a high optical magnification with a good depth of focus and thus a sufficiently bright light source.

The measuring system consists of five Lux-Cam high-speed cameras, which are used in combination with 96-W high-performance LED stroboscopes and a transparent Kistler force plate. The cameras and force plate are operated by multisensory control (MSC) software developed by Lion Systems (www.lionsystems.lu). This allows the synchronous recording of data collected from multiple sensors. The cameras and force plate are synchronized using a photoelectric sensor and custom-built control mechanism.

Foot behavior during gait, using various sports shoes, is captured from different positions—front, back, left, and right—and through the transparent force plate from below. The cameras deliver images with frame rates up to 500 Hz at full resolution. Two objective lenses developed by SILL Optics (www.silloptics.de) ensure that the cameras exhibit a depth of field of 20 m at a distance of 150 or 250 cm.

An aperture placed in the vicinity of the entrance pupil of the objective allows dynamic control of the irradiance on the camera chip. This also allows the depth of field to be extended for high-aperture images. Because of the narrow field of view on the object side of the lens (approximately 1°), changes in the reproduction ratio of the object dependent on the working distance are reduced to a minimum and it is not necessary to calibrate captured images with software.

To guarantee sufficient brightness, Lion Systems developed a 96-W LED stroboscope. With a flash duration of up to 10 μsec , images can be captured without any motion artifacts. At this speed, the runner does not perceive any stroboscopic lighting effect.

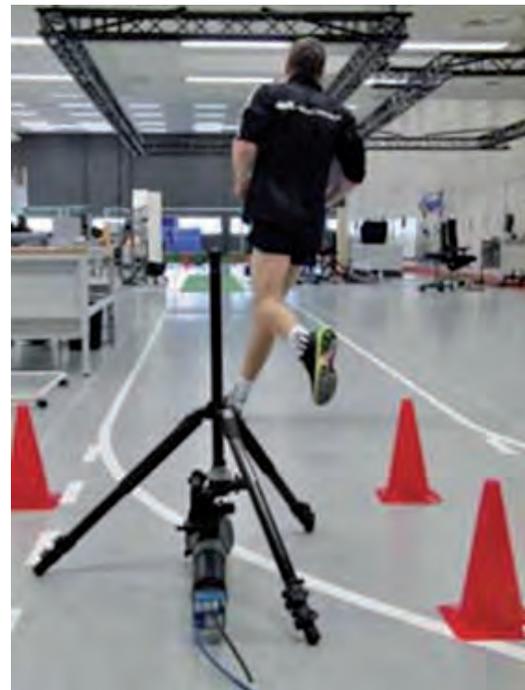


Image data captured from five different angles at high speed can be correlated with data from a force plate

Captured images allow sequences of the foot angle such as pronation—the slight inward rolling motion at a certain angle between the lower leg and the heel—to be studied (see figure). The changing of the angle of the foot happens in a limited region of the foot but very rapidly (<100 msec), and thus requires the use of a high-speed camera system. After images and force plate data are captured, the recordings are saved and can be retrieved and processed at any time.