Analysis of Runner Biomechanics Through Image Processing

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Abstract
The biomechanical features of a runner in an image can be analyzed by using certain image processing techniques, the primary method being edge detection. By constructing an accurate, two-dimensional model of a runner's lower body from a rear angle, it is possible to extrapolate the underlying qualities of that runner's biomechanics. An edge detection algorithim is applied on an image to create this outline. By comparing the results of the edge detection alogrithim input with images of the runner before and after impact, biomechanical features can be determined. In this type of situation, algorithim speed is not a very relevant issue; accuracy is far more important, the reason being that you only need to analyze a few images to create a two dimensional model of the lower body.

Background
The goal of this project is to analyze images of a runner and extract biomechanical information about the runner from the images. Among runners, a major cause of injury is over pronation. Pronation is the natural inward rolling of the ankle to absorb impact. All runners should pronate to a degree, but many runners pronate to much, causing misalignment, knee problems, and problems with the muscles and ligaments around the ankle. Using only images, the project will determine the degree of pronation of a runner, which could be instrumental in determining the proper shoe type and diagnosing injuries. The project will strictly be involved in analyzing images from a controlled environment and determining biomechanical features from analysis of images.

Methods

The first step in the process is to acquire the right images, namely, images of a runner's leg in motion, before and after foot impact with the ground. In order to increase the accuracy of the algorithm, it is important to develop a proper and uniform setup for capturing images. There are two variables that need to be constant when devising the system: image resolution, distance between the runner and the camera. Runner speed needs to be faster than jogging speed and slower than sprinting speed. In other words, the runner must be lifting up his knees, but he shouldn't be up on the balls of his feet.
With these parameters in mind, a concrete system can be devised. To capture the images, the camera is placed behind the treadmill, with the lense placed just above the treadmill running surface. In order to keep standard the distance from the runner to the camera, a piece of tape is strung out horizontally in front of the runner. The runner must run with his chest touching the tape, this way, he doesn't move relative to the camera. The video is loaded onto a computer and the frames are extracted and converted to raw images. An image taken before impact and an image taken after impact are manually selected and input into the program. Within the program, the images are prepared for edge detection using gausian blurring, noise removing techniques, and outlier removal algorithms. After preparation, an edge detection program creates an outline of the inner leg. Once the two edges from the two images are derived, the edges need to be aligned properly so that they can be properly compared. Often, one edge is larger than the other edge, so the sizes and positions of the edges are equalized. Then an algorithim is applied to both edges, in order to find the average x values of the outlines. These two values are compared, producing a pixel gap, or the difference in pixels between the two edges. The larger the pixel gap, the higher the degree of pronation. However, the output of this method, the pixel difference between the two averages, is relative to the camera resolution. The same level of pronation recorded with a camera with a larger resolution will look like more severe pronation. Thus, it is important to standardize the camera resolution or implement a system to compensate for different resolutions.

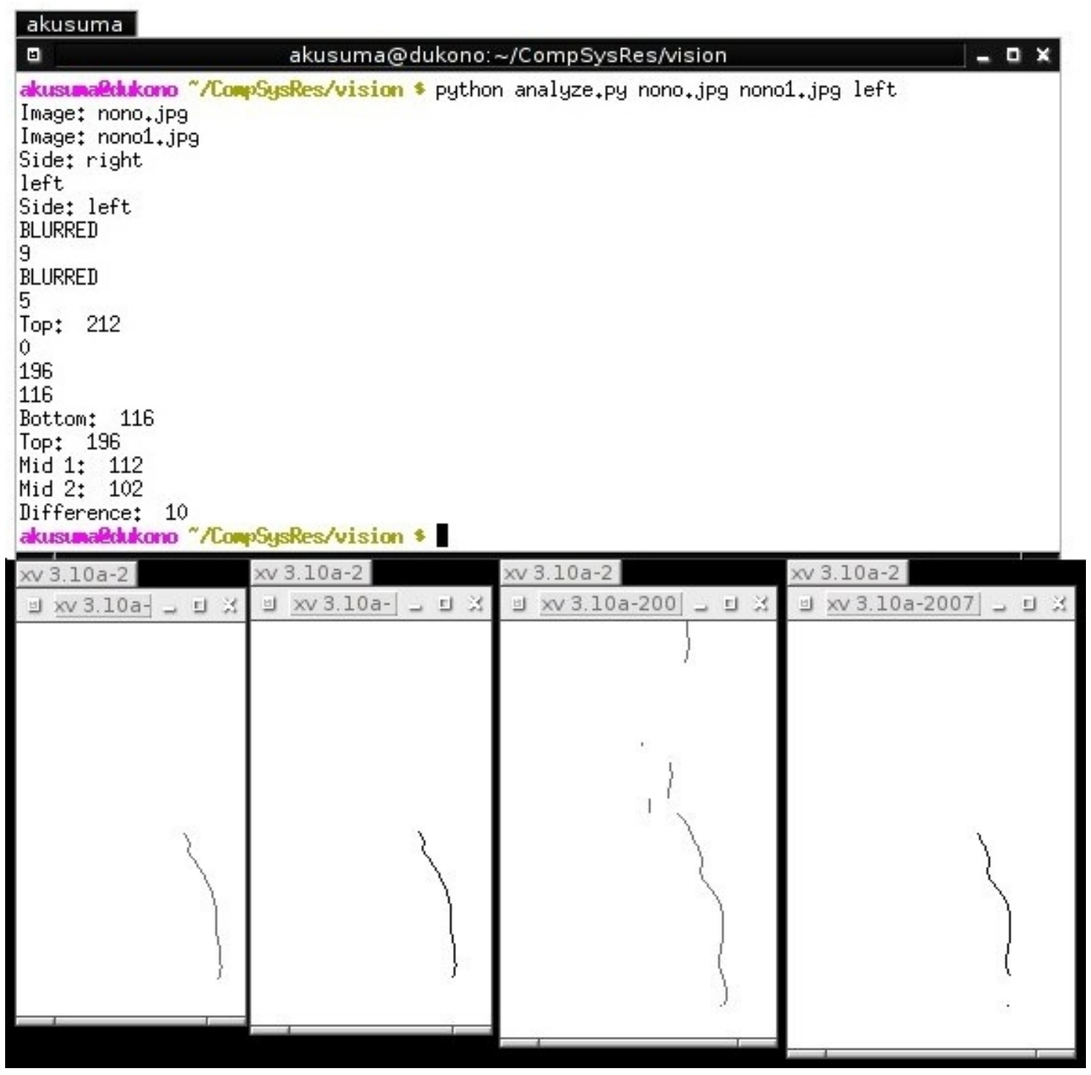

Illustration 1: The program in action