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. This is done by creating an outline of a runner's lower leg and feet. An edge detection algorithm is applied on an image to create this outline. In this type of situation, algorithm 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, as well as the fact that the time it takes to analyze a runner does not directly affect his performance as a runner.

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
Using a camera setup behind a treadmill, images of the runner are taken (Fig 2). The second step in the process is to get an outline of the lower leg and feet from an image. Using Gaussian blurring, noise removing techniques, and outlier removal algorithims, and edge detection program creates this outline. Once an outline is made, there are two possible methods for determining the degree of pronation. The first method, called the angle method, will find the degree of pronation by determining the general angle of the lower ankle and foot and comparing it to the angle of the leg. Disparities in the two angles will conclude either pronation or supernation, depending on the sign of the angle difference. The second method, the shift method, is probably the one that will be further developed in the later stages of the project. This method requires two images, an image of the runner right before and right after impact. An algorithm is applied to both images that extracts an outline and the average x value of the outline (Fig 1). These two values are compared between each image, and the higher the value, the higher the degree of pronation. However, the output of this method, the pixel difference between the two values, is relative to the distance between the runner and the camera. Thus, it is important to standardize this distance. To determine this relative factor, the program will be tested and analyzed on a multitude of neutral runners, runners with a correct amount of pronation. After storing the outputs of all the neutral runners, the outlier outputs will be discarded, and the remaining range of output values will be designated as the neutral output range. Output values above the neutral range will be over pronators and output values below this range will be superantors.

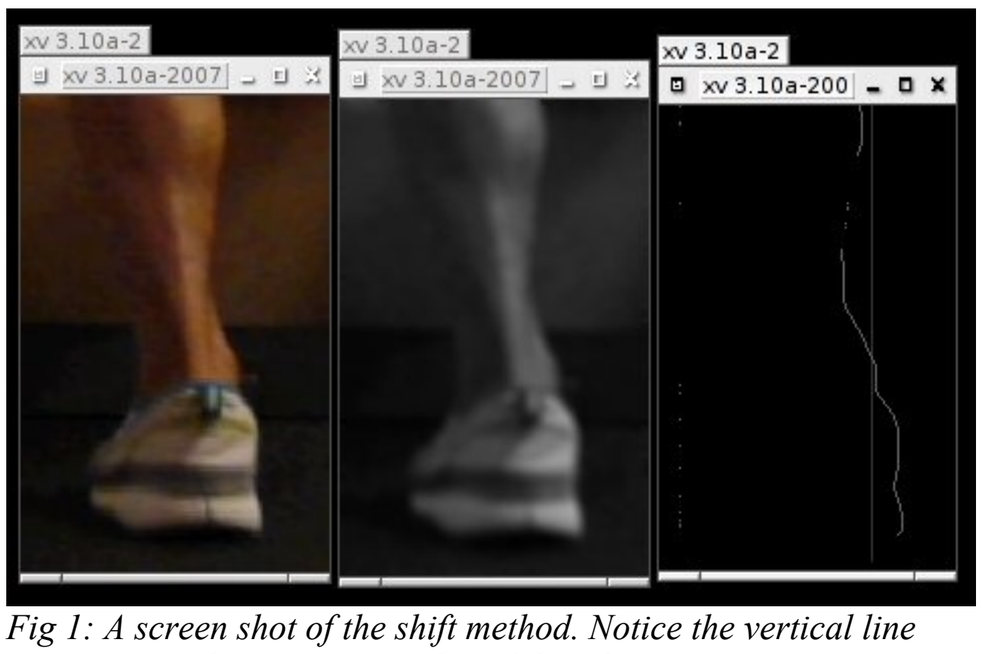

Fig 1: A screen shot of the shift method. Notice the vertical line representing the average x-value of the edge

Fig 2: The camera setup