Sound feedback for the optimization of performance in running

Jordi Bolíbar and Roberto Bresin

Sound and Music Computing Group, KTH Royal Institute of Technology

Background

Recently, auditory display has become quite popular together with visualization in order to present data or send feedback in different contexts. Psychological studies have concluded that it is really intuitive for the human brain to react to sounds, therefore, the concept of sonification has started to be used in sports and other activities that require a good body coordination and technique. There has also been previous work with sonification in a wide variety of fields, such as: physical exercise, games, and physiotherapy. At KTH we have been recently applying sonification in a couple of projects. In one project we used sonification for improving runner’s technique by analyzing the vertical displacement of the runner with a smartphone’s accelerometer [4]. Another project was about the improvement of performance in rowing [2,3]. Different sensors were placed in the boat and the oars in order to compute different information like the horizontal acceleration and displacement and send audio feedback to the rowers in order to improve their technique. In another study Barrass and colleagues [1] studied the preferences by casual runners for different types of audio feedback. This was achieved by asking runners to carry a probe logging their preferences among six sonification models. In another study, music was used in three types of sonification of the degree of motoric synchronization in active music listening [8]. The interesting contribution of this study was that the sonification itself was music that changed in different ways depending on how coordinated the movements were.

Aim

Many runners are eager to find a good technique that allows them to improve their performance and reduce the chances of injuries at the same time. By reading books or just taking some advice it is not so easy to correct your own technique, since it requires focusing on the body as a whole and not on a single part of it. That is why runners have recently been looking at new technologies that help them enjoy running even more. By tracking and analyzing the runner’s movement and sending audio feedback to her we want to design a system that allows for a more intuitive way of correct the pose while running; the runner will receive faster feedback, compared to graphic feedback, and therefore will a better possibility of adjusting the pose in real time.

Method

For the tracking of body movements we are using a Microsoft Kinect camera [5] that in combination with the OpenNI system [6] can create a virtual skeleton with 14 joints of the person being tracked. After different tests, we decided to place the Kinect facing the runner from the back, while she is running on a treadmill, and align it with the runner’s X, Y and Z axes (see Figure 1). The speed, displacement and acceleration of these joints is computed and analysed with Pure Data and then compared to the margins of theoretically good values for a correct technique. Different elements such as the vertical displacement of the torso or the distance where the foot lands from the projection of the centre of gravity are computed from that information, and depending on how close the runner’s movements get to the correct ones she will notice a change in the feedback sounds which will make her adjust the pose. This system is tested with runners on a treadmill, in order to check how useful it can be and what can be improved.

Preliminary results and Discussion

So far, an early test has been run at the Sport physiology laboratory of the Swedish Sports Confederations in Bosön [7]. Different positions and angles were tested for placing the Kinect. The best position was found to be at the back of the runner, mainly because it presents less occlusions. From the side there is a very clear view of the gait, but the arms and legs are constantly being hidden behind each other and the body. The ideal position would be from the front, but since all
the treadmills have a front panel (see Figure 1), it is not possible to track the runner. Another constrain is that the Kinect has to be exactly in the same axis as the ones we want to analyse the runner with. This means, exactly behind the runner and completely parallel to the ground. Otherwise, it is impossible to calculate many elements of the running gait that are interesting, since the references of the Kinect are completely different from the ones from the runner. Another important aspect is that the motion of the arms cannot be tracked properly, since from the rear, the hands are usually close to the chest, therefore they cannot be seen. Moreover, the elbows are usually close to the body, which makes it quite hard for the Kinect to track them. However, the information of the arms is not so relevant, and the legs can be perfectly tracked, which is our main interest. So far, algorithms for calculating the vertical displacement of the torso and the distance between the centre of gravity’s projection to the floor and the landing foot have been implemented. On the other hand, once the possibilities of the Kinect have been tested with a runner, the potential elements to sonify have been determined. Depending on the development of the project and the accuracy of the Kinect, more quantities could be taken into consideration for their sonification. The current list of identified quantities, ranked from the most to the least relevant, if the following:

1. Vertical displacement of the torso.
2. Distance between the landing foot and the centre of gravity’s projection to the ground.
3. Horizontal acceleration of the torso (this should be proportional to 2).
4. Tilting of the upper-body (forwards, backwards, and sideways).
5. Contact time of the foot on the floor.

About the sonification, since the project has not reached that point yet, so far some ideas have been studied and they will be checked once all the elements to sonify are correctly computed. Some of the sonifications that we will test are:

– Using different sound models for the sonification, such as a model for the sound of the wind, or that of the sound of a car engine, or others that have been tested in previous works [1, 2].

**Keywords**

sonification, running, kinect, performance

**References**


Figure 1: Position of the Kinect camera relative to the position of a runner on a treadmill. The red dots indicated the joints being tracked.