

AUTOMATIC CLASSIFICATION OF TAKE-OFF TYPE IN FIGURE SKATING JUMPS USING A WEARABLE SENSOR

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⁵ Supported by NSF grant IIS-1406578

Athletes in numerous sports face a potential conflict between performance improvement and injury prevention, with short term injury perceptions often superseding concerns of distant injury risks. Although it is generally acknowledged that repetitive landing impacts play a role in chronic injury development in figure skating [1], coaches and skaters do not generally track jump training volume. Activity tracking using wearable inertial measurement units (IMUs) may allow tracking of training volume but non-cyclic and continuous motion in figure skating presents numerous challenges to automatic jump detection using IMU data. In addition to tracking the number of jumps performed, tracking jump type is essential in order to effectively regulate training volume.

The overall purpose of this project is to develop an easy-to-use automated system for documenting figure skating jump training volume using a wearable IMU during a figure skating session. We decomposed this into a 2-step process that designed to be implemented on a smartphone with a simple interface. The first step is to identify a jump and the second step is to classify jump type. Our previous work demonstrates the feasibility of using a waist-mounted IMU to count figure skating jumps [2]; thus the specific purpose of this paper is to classify jump type. As a first step, we classify the jumps into two distinct take-off types: edge vs toe. Jump classification has been investigated in other sports including counting rotations by integrating gyroscope readings [3] in snowboarding. Unlike [3], we train a classifier to detect take-off type rather than integrating sensor readings to count rotations.

We collected data from 31 skaters who could perform multiple double and triple rotation jumps. Data collection and analysis were conducted as approved by our institutional review board. Each skater wore an IMU securely attached to an elastic belt placed around their waist and oriented on the lower back. The IMU system was synchronized with a high speed video camera (both collecting data at 120 Hz) using a hardware trigger system. Figure skating experts used video to annotate

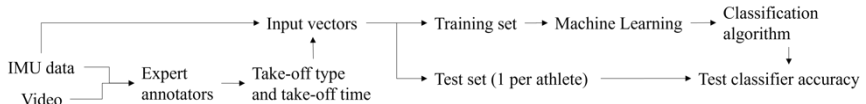


Figure 1 Development of a take-off type classifier using a wearable sensor.

jump take-off and landing events in the IMU data as shown on the left side of Figure 1. A total of 372 labeled jumps of all types were used to train a classifier.

We generated one input vector per jump. Each input vector is centered on the point of take-off and includes 60 sensor readings before and after the take-off point. We reduced input vector size and retained peaks in sensor readings by keeping the largest reading in each temporally adjacent pair of readings.

The input vectors are split into training and test sets as show in the center and left of Figure 1. The training set along is used as input to the AdaBoost function in scikit-learn [4] version 0.21.3 with default parameters. We trained other, but ultimately less-accurate, classifiers using the same sets of input vectors using other algorithms and boosting methods. Test sets in cross validation consisted of all jumps by a single athlete. Take-off type classification using AdaBoost trained on input vectors as described above achieved an F1 score of 0.92 when classifying edge and toe take-offs. The reported F1 score is the average of F1 scores across all 31 athletes weighted by jump count.

Our results suggest that data from an IMU worn on lower back can be used to automatically classify take-off type in figure skating. We have incorporated the classifier into a jump counter on a mobile phone paired with a wearable IMU for use during figure skating practice. This work is an important step toward future work involving the collection of objective training data from wearable sensors to enhance athletic performance and inform injury prevention strategies for figure skating and perhaps other sports.

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