Abstract

The behaviour of a construction safety net and its supporting structure was monitored with a high speed camera and image processing techniques. A 75 kg cylinder was used to simulate a falling human body from the upstairs floor of a building under construction. The cylinder rolled down over a ramp until it reaches the net. The behaviour of the net and its supporting structure was analysed through the movement of the cylinder once it reaches the net. The impact was captured from a lateral side with a high speed camera working at 512 frames per second. To obtain the cylinder’s position each frame of the sequence was binarized. Through morphological image processing the contours of the cylinder were isolated from the background and with a Hough transform the presence of the circle was detected. With this, forces and accelerations applying on the net and the supporting structure have been described, together with the trajectory of the cylinder. All the experiments have been done in a real structure in outdoors location. Difficulties found in the preparation of the experiment and in extracting the vibrations with a pocket digital camera and sub-pixel resolution can be obtained from the cylinder trajectory. Since the results can be obtained from the cylinder trajectory and the maximum deflection of the net and the maximum deceleration suffered by the cylinder. All these results can be obtained from the cylinder trajectory. The cylinder diameter is known, we can calculate the px to mm conversion factor and thus obtain the real movement of the cylinder.

After the video capture, the sequence is moved from the camera to the computer and processed off-line with Matlab. The first frame of the sequence is presented to the user and forces and accelerations applying on the net and the supporting structure have been described, together with the trajectory of the cylinder. All the experiments have been done in a real structure in outdoors location. Difficulties found in the preparation of the experiment and in extracting the vibrations with a pocket digital camera and sub-pixel resolution can be obtained from the cylinder trajectory. Since the results can be obtained from the cylinder trajectory and the maximum deflection of the net and the maximum deceleration suffered by the cylinder. All these results can be obtained from the cylinder trajectory. The cylinder diameter is known, we can calculate the px to mm conversion factor and thus obtain the real movement of the cylinder.

Method

- **Experimental setup**

  All the experimental setup was arranged in a building structure. In order to simulate the falling body, a 75 kg cylinder was dropped from a height of 4.33 m over a 60° sloped surface until it reaches the protection system (Fig. 1). Two different protection systems were used here. One of them used a net made of textile thread net while the other is made by a steel wire mesh. The supporting structure of the protection system was common to both nets. This structure was anchored to the ground by two dead weights. For each kind of surface two experiments were made. The movement of the cylinder was recorded by a high speed camera located in one side of the experiment. The camera used in this experiment was an AOS X-Pri, working at 512 fps with a frame resolution of 800 x 560 px. In this video sequence some simple shapes can be tracked for determining object movements.

- **Image processing algorithm**

  Detection of the cylinder position consists of two basic steps. In the first step, the scene is binarized and the borders extracted. The image is cleaned in order to remove as much noise as possible. In the second step, the presence of a circular shape is detected by means of the Hough transform. In order to facilitate and accelerate the calculation, the position of the cylinder and its radius is manually estimated in the first frame. For the remaining frames of the sequence, the process is fully automatic. From the first image, the algorithm runs automatically and detects the position of the cylinder at each frame (Fig. 3). After doing this process in all frames, the complete trajectory is obtained (Fig. 4).

Results

The main results of this work are the maximum deflection of the net and the maximum deceleration suffered by the cylinder. All these results can be obtained from the cylinder trajectory. Since the cylinder diameter is known, we can calculate the px to mm conversion factor and thus obtain the real movement of the cylinder. A least-squares fitting of the trajectory to a polynomial equation was done. Different degrees of the polynomial equation were used to assess the stability of the result. Second derivative of the fitting expression gives the cylinder acceleration (Fig. 5).

Finally, it was found that steel wire mesh fulfills the recommendation of a minimum deflection of 200 mm but with a deceleration of 30 g, too much for a human body. Relatively safe values of acceleration were obtained for the textile thread net, but with deflections between 2.5 and 3.5 times higher than the minimum values required by European Code 3.

References

