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Comparison of Two Interpolation Methods for Resampling Center of Mass Velocity Data

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A B S T R A C T

Data interpolation methods are highly useful for estimating missing values. Another usage of these methods is resampling the measured data. In the field of biomechanics sometimes researchers have to deal problems related to data acquisition rate or sample size. Using linear or polynomial interpolation methods, it is possible to overcome these problems. However, choosing right interpolation method is very critical. In this short report two interpolation methods with very similar estimations were compared. Results showed that, even the interpolation curve fits most of the data, the overall appearance can be misleading.

Key words: *Data acquisition, interpolation, spline, polynomial, velocity*

Introduction

Analyzing and interpreting kinetic and kinematic variables of a biomechanical research can sometimes be problematic with regard to data acquisition rate (DAR) of measurement devices. One reason of this condition is the fixed DARs. For example, some video cameras give fixed frame rates per second (30, 60 or120) and for the most of the camera models it is not possible to interfere to the frame rate by third party software. If these two conditions come together, there is no other option than recording video at given frame rate. Supposing that video was captured one of these cameras at 30 fps. Therefore, each frame would correspond to every $0.0\overline{3}$s or if the other frame rates are used, times for the frames would be every $0.01\overline{6}$s and $0.008\overline{3}$s respectively. As might be expected, dealing with repeated decimals during the analyses or presenting them on the plots are not favorable for the researchers. Instead of repeated decimal numbers, working with plain decimal numbers gives easy and clear understanding during analyses or interpretations. Another difficulty occurs when multiple data acquisition devices with different DARs are used (Smołka & Skublewska-Paszkowska, 2014). Usually, measurement devices produced by the same company are compatible with each other. However, these kind of measurement systems are quite expensive and for the most of the researchers or laboratories it is not financially easy to have these systems (Hamill et. al., 1997). As is seen some studies (Blackburn et al., 2013; Mueller et. al., 2011; Zelle et. al., 2007) most of the time, researchers have to collect data via devices with different DARs for a measurement For example, if force or electromyography (EMG) data, that can be collected only at 10 Hz and multiples (limited by the device), would like to add a measurement in which aforementioned video cameras are used, it would be not possible to show data samples on the same time frame because of unequal sampling intervals. In this case, there are two solutions. In first, the DAR of the force plate or EMG can be equalized with the frame rate of the cameras, which is a pointless effort. Because, measuring these variables at 30 and 60 Hz (even 120 Hz) will be resulted huge amount of data loss. In second, the kinematic data can be resampled after direct linear transformation (DLT) process of kinematic analysis, using interpolation methods. There are several kinds of interpolation methods. Polynomial and spline interpolation methods are the most popular interpolation methods. However, literature review showed that the usage of interpolation methods in swimming biomechanics is pretty low than expected. Therefore, in this short report third order (cubic) polynomial interpolation and cubic spline interpolation methods were compared to find out which one of these methods fits better a velocity data obtained from swimming kick start.

Method

A swimming kick start's block phase recorded at 60fps and using a motion analysis software (Skillspector), the velocity of swimmmer's CM in anterio-posterior axis from starting signal to take-off was calculated. In addition, one axis (horizontal) force data collected at 100 Hz. For the purpose of equalizing sample sizes of these two measurements, 60 Hz velocity data were resampled to 100 Hz using cubic polynomial and cubic spline interpolation methods via Systat Software's SigmaPlot Ver. 12. After resampling, two data were compared using Mann Whitney U test.

Results

Mann Whitney U test results showed that the resampled data using polynomial and spline interpolation methods were not statistically different, $U = 4099$, $p = .907$. On the other hand, according to descriptive statistics, the maximum velocity estimated by the polynomial interpolation method respectively higher than both raw data and the data interpolated by spline equation (see Table 1).

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Table 1. Descriptive statistics of raw and resampled data

	n	*M*	*SD*	Min	Max
Raw	56	.89	1.27	-.15	3.73
Polynomial int.	91	.88	1.23	-.11	4.22
Spline int.	91	.84	1.22	-.17	3.72

Scatter plot of the raw data and interpolation curves revealed that polynomial interpolation method gives a smoother curve than spline interpolation method (See Figure 1). However interpolation curve missed the important fluctuations in the middle of the data series. Also, at the end velocity curve increased more steeper than the other data series.

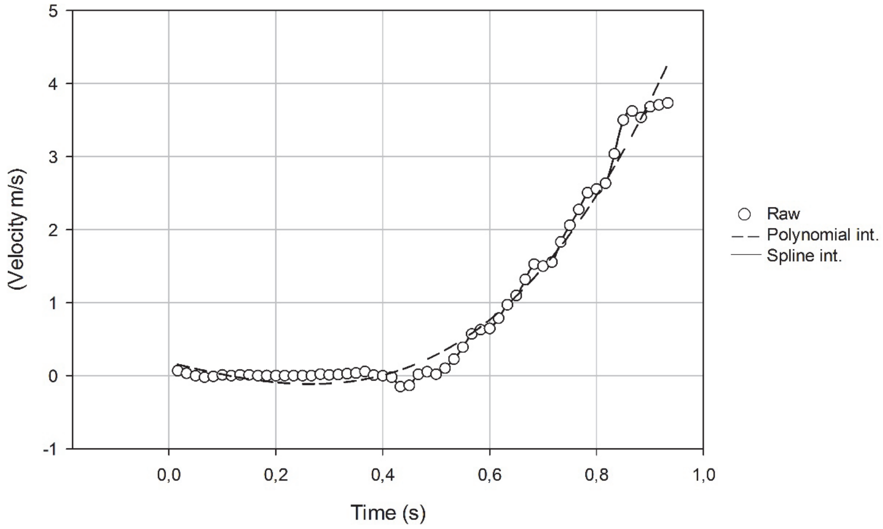

Figure 1. CM velocity of swimmer

Discussion

Even single bent velocity curve was favorable for cubic polynomial interpolation, when this method used backward move of swimmer's CM at the beginning of the movement can be overlooked. In addition, especially at and the end of the data, velocities were quite higher than calculated ones. Yet, the R-squared value of the polynomial interpolation was .98, the difference between calculated max and estimated max velocity is significantly important. Because approximately .50m/s difference in the CM velocity can give a wrong impression about the performance. On the other hand, when cubic spline interpolation method was used, the interpolation lines smoothly followed the actual data and also there was no miss interpolation at the edges. The main disadvantage of using polynomial interpolation is that, these methods give a single model for the entire data set. However, the spline interpolation method uses a piecewise continuous function composed of several polynomials and also spline interpolation line passes through all predefined data points which decreases the residuals significantly. In conclusion using spline interpolation method to resample velocity data gave more robust results than cubic polynomial interpolation. The spline interpolation method is strongly advised to the researchers who needs to resample their data.

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