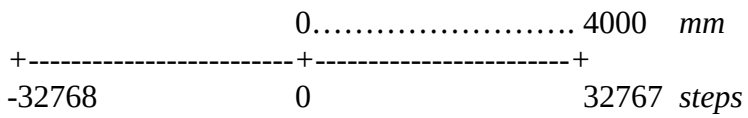
Scaling Issue with BodyBuilder

All Vicon BodyBuilder output data written with the BodyLanguage "output()" command are stored as "3D points". In the C3D file format, these points were originally intended to represent marker position data within a calibrated volume. Hence, the data would be homogeneous in the sense that units and relative scales would be the same. With the integer DEC file format, these data are stored as a 2 byte word (or integer) variable type which is multiplied by some real scaling factor (SF) to yield a floating point value. The signed word variable type represents an integer value from –32768 - 32767. The scaling factor is dependent upon the calibration volume such that the greatest precision is allowed over the entire volume of interest. For example, if the largest dimension of the calibration is 4 *m*, then, assuming the calibrated volume begins at the global (0,0,0) reference location and contains only positive X-direction points with the largest dimension being X=4 *m*, the scaling factor for length units expressed in *mm* would be

SF = 4000 *mm*/32767*step* = 0.122 *mm/step*



Thus the resolution of the spatial locations is

resolution = 1 *step* * 0.122 *mm/step* = 0.122 *mm*

Problems can occur within BodyBuilder as the scale of the output parameters reaches that of the scaling factor or resolution. For instance, moments in a system with dimensional units of *mm* and force units of *N* would be computed in units of *Nmm*. Prior to output, users may wish to scale the values first within BodyBuilder by dividing by 1000 to obtain the more commonly used units of *Nm*. Further, users may wish to divide by the subjects body weight for normalization to obtain units of *Nm/kg*. Conversion from *Nmm* to either *Nm* or *Nm/kg* can easily result in values on the order of 1 or even 0.1 which are significant in the context of their biomechanical importance. Due to the scaling factor, however, using the example above, only 8 numbers (steps) would be available to store values between 0 and 1 and all values between 0 and 0.1 would be treated as 0.

The loss of resolution results in loss of the actual values and "stepped" graphs for variables with small numbers. This is not apparent until the C3D file is first saved and reloaded into BodyBuilder or another program. The internal calculations in BodyBuilder retain the actual floating points until the file is saved in the DEC format. Therefore graphing initial results within BodyBuilder does not reveal the problem..

The same problem results in some angular outputs where angles are small. While it is likely that most angles may not be measures accurately to less than 0.1°, the effect described above will lead to “coarse” appearing graphs if the scale is of the axis is small enough. This can be avoided by multiplying ‘small’ angles by a factor of 10 prior to output (giving a maximum possible number of 3600). When users attempt this upward scaling, they should be careful not to exceed the upper or lower range of the scaling factor (+/- 4000 in the example above).

There are several ways to avoid this scaling problem. Perhaps the most obvious is to be aware of the units and the ranges of interest as well as the resolution of the system and to scale (or don’t scale) appropriately within BodyBuilder, then use post-processing software to obtain the actual units of interest. A second, and perhaps better solution, is to specify the use of “real” data type C3D file format as opposed to the “integer” format. Users should be careful that any post-processing software used to manipulate the resulting C3D files can appropriately read the “real” data storage format (Vicon Clinical Manager [or VCM], for example, cannot). Finally, in some cases specifying length units in dimensions of *m* instead of *mm* may be more appropriate, although this may create the opposite case of the resolution being too fine and the range not great enough.

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