White paper

Quantifying jerkiness

Jerk-free movements in Axis positioning cameras

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1. Introduction

Positioning cameras from Axis offer jerk-free pan and tilt movements. Whether ultra-slow, providing smooth panoramic viewing, or high-speed, putting operators on the spot in an instant, the panning and tilting movements are uniform and free from visible jolting or shaking.

This document explains what jerky, or jerk-free, movements are, how Axis measures jerkiness, and why that method was chosen.

2. Measuring jerkiness

At Axis, the jerkiness of a camera movement is quantified using the standard deviation of the velocity, calculated at low speed. Standard deviation is a commonly used and proven way for computing how much a set of data values vary from a nominal value.

The standard deviation of the velocity has been measured to be less than ±0.01°/s in Axis positioning cameras. This variation is so small, thanks to sophisticated motor control, that the camera movements are perceived as jerk free.

See Section 3 for details about velocity variations and their effect on the viewing experience. See Section 4 for definition and examples of standard deviation.

3. Velocity variations and perceived jerkiness

Consider a camera panning, with low velocity, over a stationary object. If the velocity is constant, the object will appear to move an equal distance on the screen between every frame (see Figure 1). The object will always show where expected, that is, as predicted from previous frames.

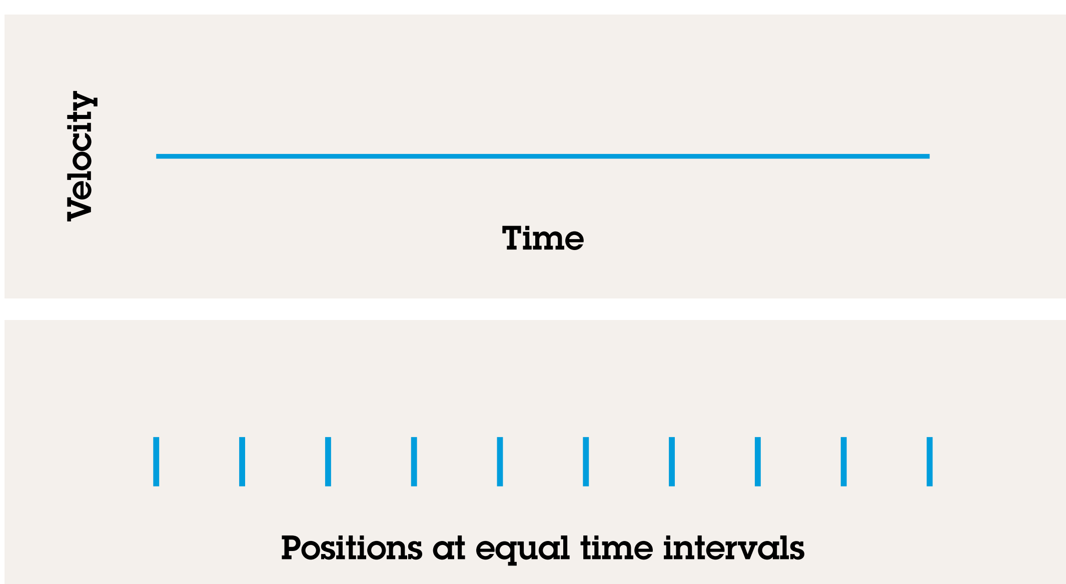

Figure 1. Completely jerk-free camera movement. The upper part shows camera velocity being constant over time. The lower part represents the position of the observed object changing an equal distance with each frame.

If the velocity is not entirely constant, the object will appear to move a non-equal distance between frames, and seemingly make a jump to another place than where expected (see Figure 2).

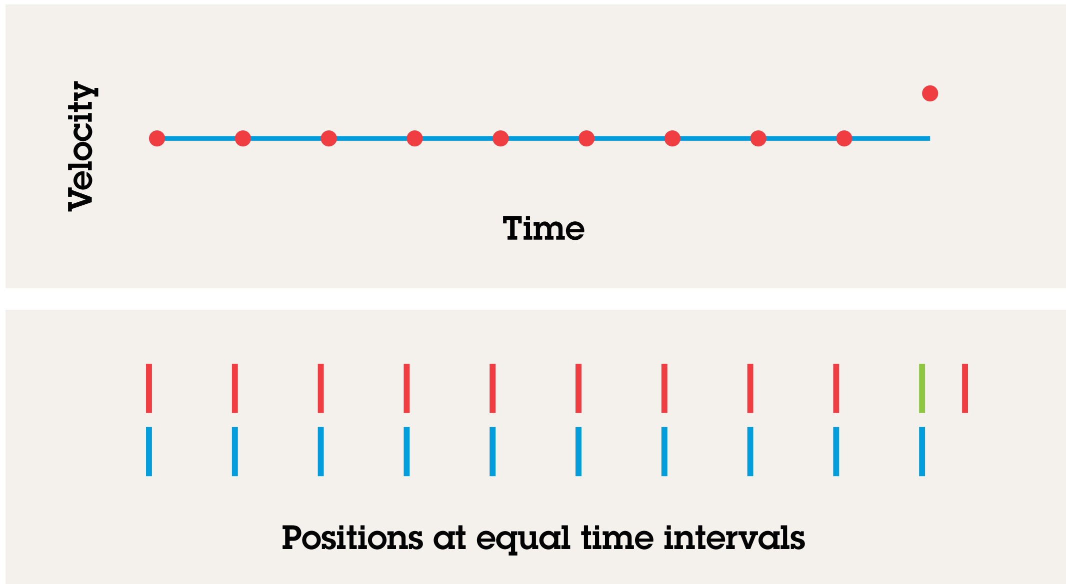

Figure 2. Camera movement with a single jerk at the end (represented in red), compared to constant movement (represented in blue). The lower part shows the observed object "making a jump" to a different place (red) than expected (green).

A larger velocity variation (larger amplitude) will be more noticeable, and a longer duration of the variation will be more visually disturbing. Standard deviation is defined to emphasize such variations, making it a very suitable method to quantify the jerkiness.

When observing a moving object, a camera can be set to keep the object constantly centered in the image. In that case, camera velocity variations will prevent the object from staying centered. The erratically moving background will also cause a visual disturbance that adds to the perceived level of jerkiness.

Some commonly occurring types of velocity variations are shown in Figures 3-5 below.

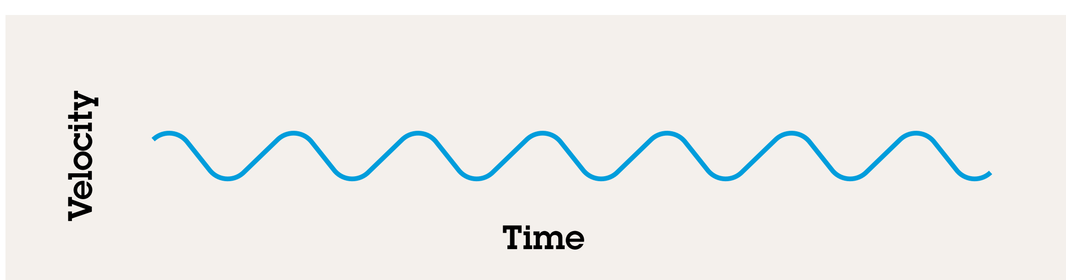

Figure 3. Sinusoidal velocity variation. This type of variation is present, to some degree, in most motion systems.

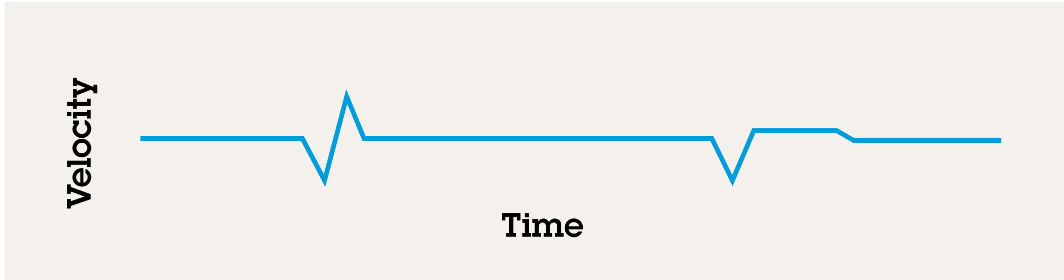

Figure 4. Velocity with irregular disturbances, first symmetric and second asymmetric. Such irregular drops and peaks may be caused by, for example, momentarily increased load or friction. They will always have both positive and negative components.

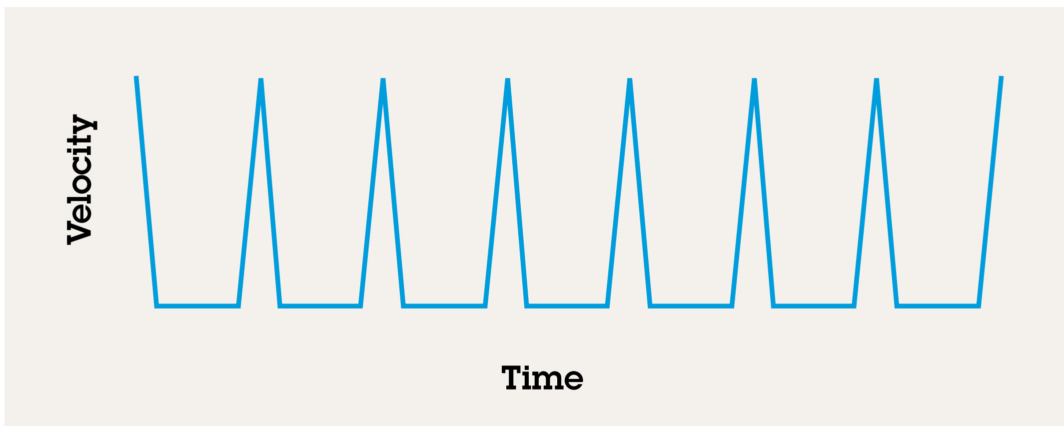

Figure 5. Stop-and-go motion: periods of more or less complete stand-still with movement occurring in short bursts. If the movement was supposed to be constant, the peaks will always be high since they must compensate for all the movement that was lost during the stand-stills.

4. How is standard deviation calculated?

Standard deviation is a commonly used and proven measure for quantifying how much a set of data values vary from a nominal value. The standard deviation is usually represented by lower-case Greek letter σ (sigma).

The standard deviation of a set of data values is defined as:

$$\sigma = \sqrt{\frac{1}{N} \cdot \sum_{i=1}^{N} (x_i - \bar{x})^2}$$

where $\bar{x}$ is the mean value and N is the number of data values. (A slightly different definition can be used if the data values are part of a larger number of samples).

Step by step, the calculation can be done as follows. For reference, see the plots in Figures 6, 7, and 8, where data samples, mean value, error, and standard deviation are marked in different colors.

1. Consider the data values (blue).
2. Calculate the mean value (red) of the data values.
3. For each data value, calculate the error (green) as the difference between the data value and the mean value.
4. Take the square of each error. This makes all errors positive, so they don't cancel out, and it puts more emphasis on large errors.
5. Take the mean of the squared errors. This is the variance, σ^2.
6. Take the square root of the variance to get the standard deviation.

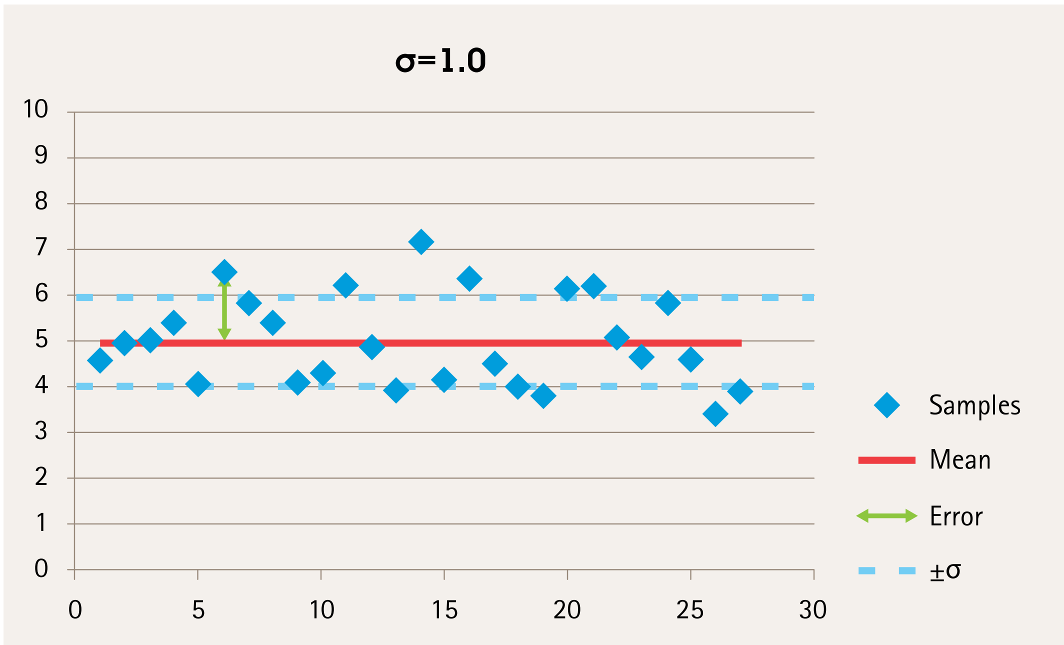

Figure 6. Data with a standard deviation of 1.

For a visualization of how the standard deviation correlates directly to the variation in values, compare the example in Figure 6, where σ=1, with Figure 7 (σ=2) and Figure 8 (σ=0.5).

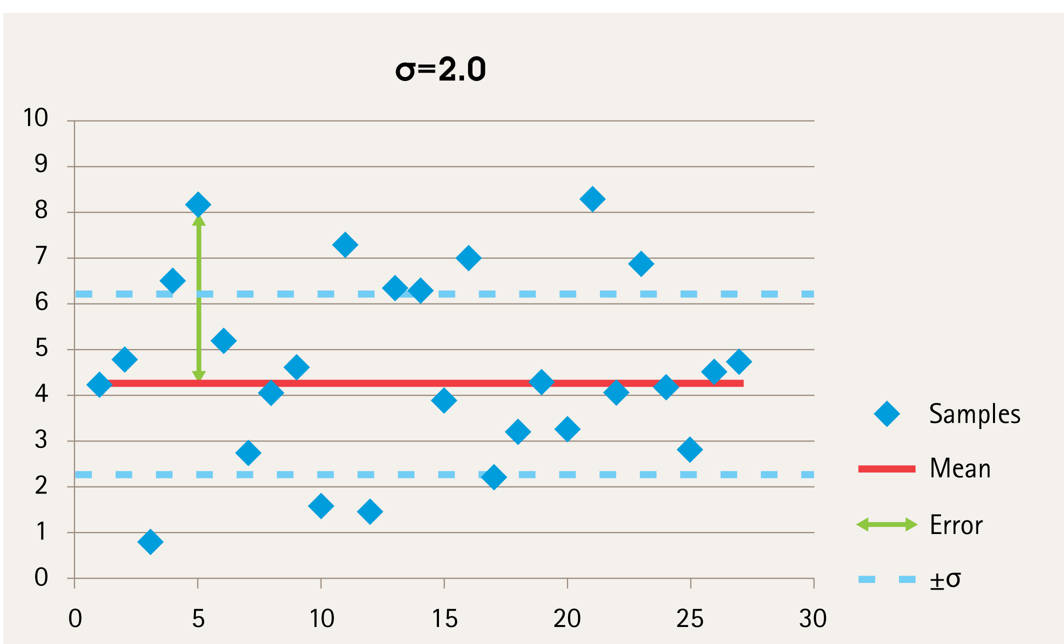

Figure 7. Data with a standard deviation of 2.

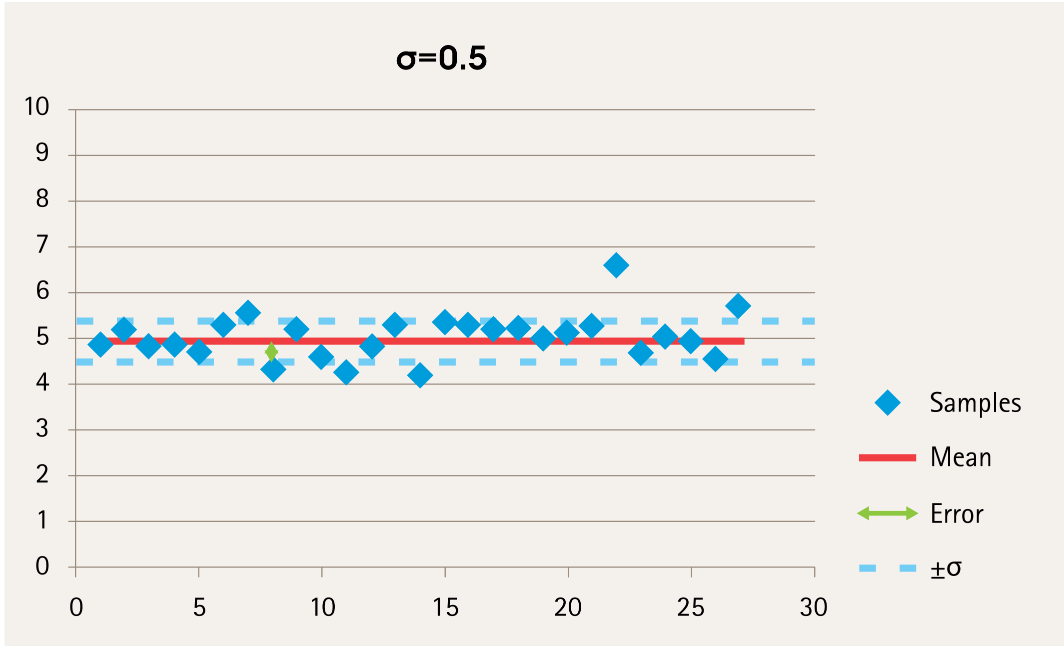

Figure 8. Data with a standard deviation of 0.5.

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About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the global market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to its customers and carried through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 2,700 dedicated employees in more than 40 countries around the world, supported by a network of over 90,000 partners across 179 countries. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ OMX Stockholm under the ticker AXIS.

For more information about Axis, please visit our website www.axis.com.