BUSII

Team 3

November 21, 2018

Contents

1 Visual Analysis of New Data

We were given a different, much smaller data set which includes both line numbers for indicating the progress in the driver program and rotational axes.

1.1 Line numbers

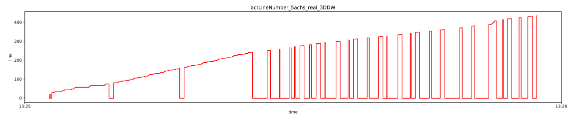
The line numbers are fairly straight forward: they are an integer, taking some positive value or -2. We assume -2 means that the program is stopped. This is very well-behaved data which clearly shows what is going on, which is a breath of fresh air. Figures 1a and 1b shows the line numbers for both processes visualized as step functions over time.

Both processes appear to behave quite similarly. They can roughly be divided into three first segments which end with a stop, and then the latter half contains many stops. We can only assume that the work done later is either more difficult, requiring stops to recalibrate or check things, or that it is a simple finishing step which requires human checks whether it is finished.

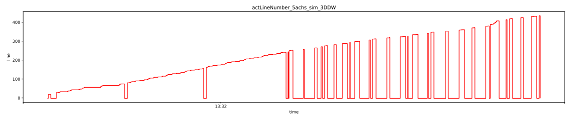
The question however is as always: but what do they *do*?! To this end, take a look at the other plots of Figure 1. There we can see that the two processes look very different. The *sim* process looks almost pretty with its wavy curves—but most important of all, look at the magnitudes of the values. They are *much* lower than for the *real* process—it is thus pretty clear that *sim* probably stands for "simulated", and the machine did not actually mill, but only went through the motions, possibly performing the probing routine. We've left out the axis speeds because the two plots are quite similar.

1.2 Rotation of coordinates

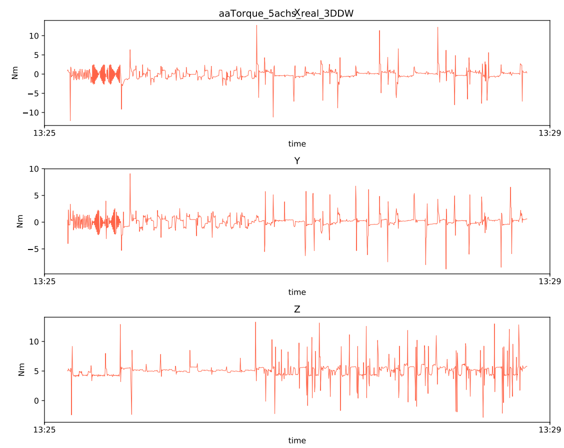
The other interesting thing about this data set is the inclusion of the B and C axes. They are both rotational axes, with B rotating around the Y axis, and C around the Z axis.



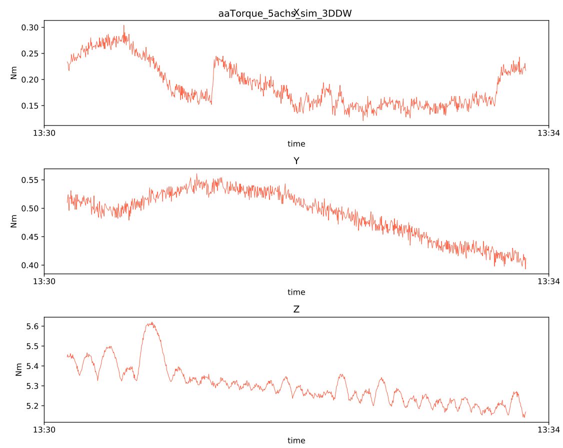
(a) Line numbers for the "real" process



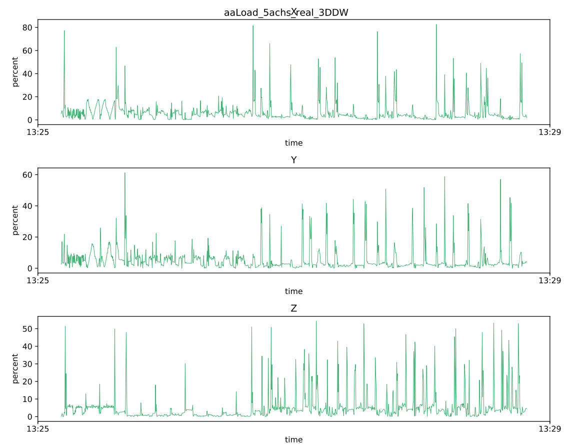
(b) Line numbers for the "sim" process



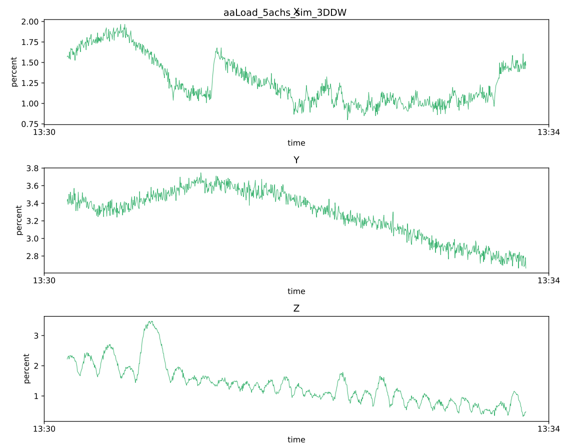
(c) Torque for the "sim" process



(d) Torque for the "sim" process

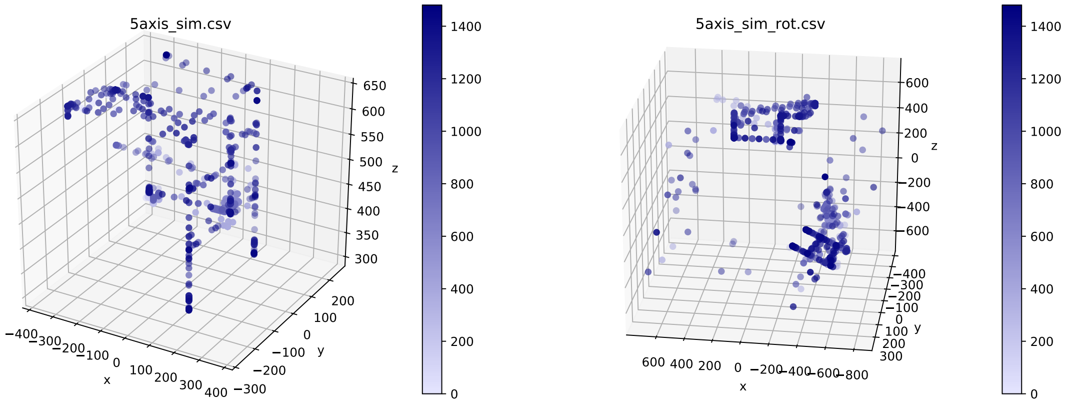


(e) Drive load for the "sim" process



(f) Drive load for the "sim" process

Figure 1: Plots illustrating differences between the two processes



(a) Coordinates of simulated process

(b) Attempted rotation

Figure 2: Sad caption

At first we thought this would be easy—we will construct a rotation matrix R_{BC} and transform the vector $v = \begin{pmatrix} x & y & z \end{pmatrix}^T$ by doing $v' = R_{BC} \cdot v$ and there they are, the actual coordinates. However, this assumes that the rotation is occuring around the origin, which does not seem to be a valid assumption.

We assume that this is invalid because it does not work. Although some structure is revealed, it looks weird and incomplete, and it seems like there still are two parts that should be connected, but are not.

We took to the internet and found out that what we are interested is *CNC kinematics*. We found this link `http://linuxcnc.org/docs/devel/html/motion/5-axis-kinematics.html`, which has some illustrations that might be helpful, but at present are mostly overwhelming.

The possible explanations for this are (1) it is more complicated than we first assumed, (2) we did something wrong, or (3) and most likely, both. However, the most pressing issue right now seems: where is the pivot. Which point in the (x, y, z) space are the B and C axes rotating around? It does not seem to be the origin, and figuring this out from the data seems not very possible.

One issue that must be fixed is that the order of rotation needs to be considered—matrix multiplication is not commutative and thus it makes a difference whether we rotate around B and then around C (resulting in the rotation matrix $R_{CB} = R_C R_B$). Currently we are assuming that this is done in the reverse order for no particular reason.

Figure 2 shows our failed attempt at reconstructing the object using rotation.