ATL Take-Up System Identification

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*Abstract*— It is proposed that on the new ATL heads that the dancer system be removed and replaced with a servo control loop that applies torque in order to reach steady state tension in the web. In order to accurately calculate the tension in the web, a system identification must be conducted to understand the frictional and inertial characteristics in the system.

# Introduction

The core assumption of this system identification method is that friction behaves as the sum of Coulomb and viscous friction. Using a first principles a Laplace domain model is easily formulated for the mechanical system. The problem of system identification in this case will be solved using least squares in the time domain after conducting experiments to approximate Coulomb and viscous friction.

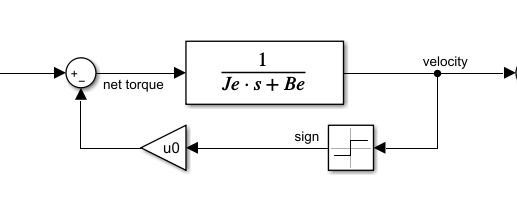


Figure 1 – Laplace domain model of mechanical system

# Model

The model of the system is derived from a sum of torques on the reflected inertia .

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Where:

is the motor torque

is the disturbance torque modelled by Coulomb friction

is the viscous friction torque

is the reflection inertia

is the angular acceleration of the input shaft

Furthermore, the friction functions can be written in terms of the angular velocity. Therefore, we can rewrite Eq. 1 shown in Eq 4.

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At this point, it is clear that the Laplace transform of the system results in the block diagram shown in Figure 1.

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# Algorithm

The first thing to note is that there are many different servo controller systems and software. Sometimes there are built in functions to measure frequency response and even identify plant models and friction characteristics. Therefore, if there is a built in tool that can reliably calculate the parameters this section can be skipped.

In this algorithm it is assumed that Coulomb friction can be approximated via experiment and taken at face value. Afterward, the quantities are optimized via a least-squares algorithm in the time domain.

The algorithm assumes that the following signals can be measured:

the torque sent via the amplifier

# Estimating number of trials

Let be the number of trials and be the number of outliers in the set of registration points. Some basic properties of this algorithm are listed:

1. As grows, the probability of failure decreases
2. As grows, more computational time is necessary
3. As grows relative to the probability of failure increases for a given

Thus, can be increased to offset the effect of increased likelihood of outliers at the cost of computational time.

Let be the probability of randomly sampling 4 inlier points in a set of . We can compute with Eq. 1.

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We define as the probability of failure we are willing to accept. Then we must find the minimum value that satisfies the inequality in Eq. 2.

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Note that computing can cause overflow issues so it makes to compute the ratio of factorials instead. A function shown in Eq. 3 is useful to avoid unsigned-integer overflow issues and can be easily constructed using a while loop.

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Then we can just evaluate two times to find without worry of overflow since should be small.

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Example Calculation

Suppose that we want a registration set of 7 to be robust even in the presence of 2 outliers.

Let

Substitution into Eq. 1 yields and can be calculated

Assume we want a better than 1/1,000 chance of success in the presence of 2 outliers.

Thus, we should run the RANSAC loop 45 times if we make this assumption. Interestingly if we exhaustively choose all sets of 4, there are only 35 combinations. We see that in the case of small sets of registration points, it is sometimes more efficient to compute exhaustively all registration subsets. However, computing 45 iterations of the RANSAC algorithm happens in approximately 5 seconds, which is a small fraction of the total time spent on this process.

# Exhaustive computation

In the case of small registration sets, it becomes worthwhile to exhaustively compute all the combinations of registration targets. The reason is that the number of trials can be similar to the number of combinations. Furthermore, computing all combinations means that if there is a set of 4 points that are considered inliers, the algorithm will work properly as it will be one of the combinations. Exhaustive computation becomes infeasible quickly as the number of registration targets rise, however, in most use cases with it is feasible.

# RANSAC Data Filter

A further step can be done to get a more accurate transform. After finding a reasonable transform using RANSAC, we can filter all outliers out of the data set and compute the best fit transform on all inlier data sets. The hope is that by using more points the random errors will cancel to give a more accurate transform.