Statistical analysis of Gyroscopic data to determine machine health in Additive Manufacturing

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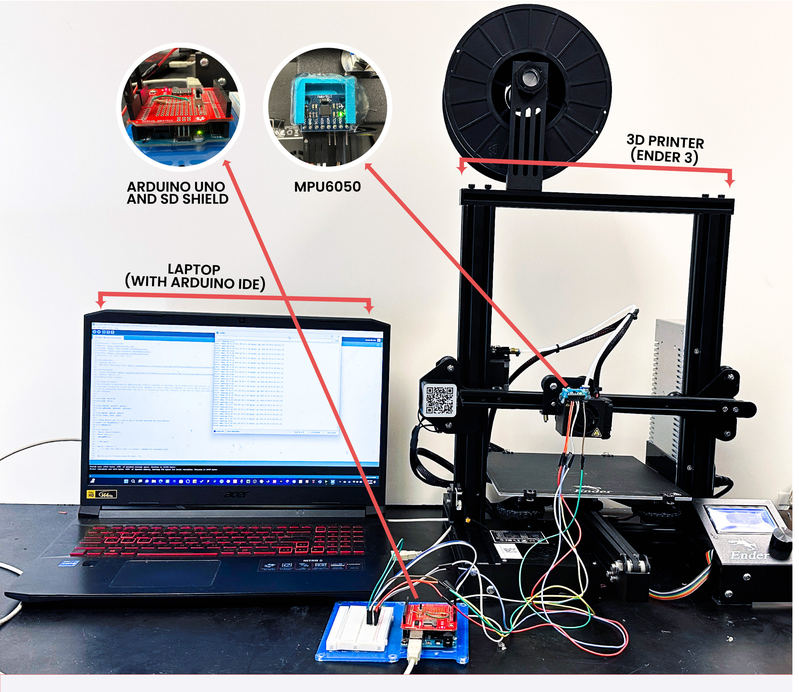
ABSTRACT

Additive manufacturing, commonly known as 3D printing, has significantly advanced part fabrication in various industries. Despite its numerous benefits, including reduced lead times and complex geometries, a few obstacles still prevent widespread adoption. Current research efforts have predominantly focused on in-situ monitoring and investigating the mechanical properties of 3D printed materials, with limited attention given to the sources of skewness in the fabricated products. To address this gap, our study aims to explore the factors contributing to skewness in 3D-printed objects. Specifically, we examine the influence of the belt and carriage wheel conditions within the 3D printer on the shape of the fabricated products, resulting from potential distortions in the orientation of the print head carriage during the printing process. A comprehensive analysis was employed, utilizing One-Way ANOVA, Tukey, Fisher Least Significant Difference Method, and Friedman Rank test, to establish statistically significant evidence supporting the notion that the mechanical components, namely the belt, and wheel, have a substantial impact on the orientation of the print head, consequently leading to skewness in the final 3D printed products.

EXPERIMENTAL DESIGN



EXPERIMENTAL PROCEDURE

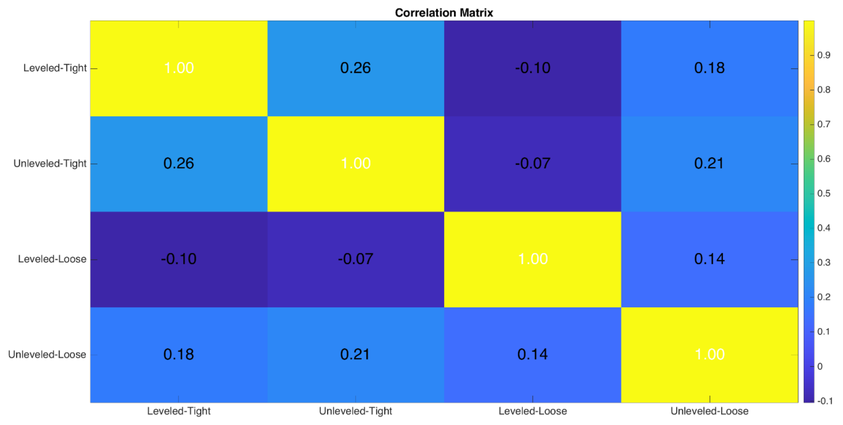
1. Home the carriage in x, y, z position
2. Raise the z-position to 50mm
3. Pause for 15 secs for calibration
4. Drive carriage from x=0mm to x=200mm at a speed of 1000mm/min
5. Repeat step 4 ten times by moving back and forth.
6. Collect data using MPU6050 in step 5
7. Repeat for each condition

EXPERIMENTED CONDITIONS

The Conditions under consideration are:

1. Leveled Belt – Tight Wheel,
2. Unleveled Belt – Tight Wheel,
3. Leveled Belt – Loose Wheel, and
4. Unleveled Belt – Loose Wheel.

CORRELATION MATRIX



The correlation matrix analysis revealed that either uncorrelated or weak correlations were observed among the data collected for each condition. This finding suggests that variations in the condition of the belt and wheel of the 3D printer directly corresponded to changes in the orientation of the print head carriage. The lack of strong correlations or the presence of weak correlations between the collected data indicates that alterations in the belt and wheel conditions had a noticeable influence on the orientation of the print head carriage.

DESCRIPTIVE STATISTICS

Conditions	Mean	Std. Dev.	Variance	p-Value
Leveled Belt – Tight Wheel	4.572	0.027	0.00075	0.244
Unleveled Belt – Tight Wheel	5.668	1.325	1.755	<0.005
Leveled Belt – Loose Wheel	5.015	0.669	0.448	<0.005
Unleveled Belt – Loose Wheel	13.947	4.289	18.391	0.808

HYPOTHESIS

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	$\alpha = 0.05$

ONE-WAY ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Machine-Condition	1	1318.5	1318.46	143.37	0.000
Error	58	533.4	9.20		
Total	59	1851.8			

TUKEY'S TEST

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Unleveled Belt-Loosed Wheel and Leveled Belt-Tight Wheel	9.375	0.783	(7.808, 10.943)	11.97	0.000

LSD TEST

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Unleveled Belt-Loosed Wheel and Leveled Belt-Tight Wheel	9.375	0.783	(7.808, 10.943)	11.97	0.000

FRIEDMAN RANK TEST

Null hypothesis	H_0: All treatment effects are zero
Alternative hypothesis	H_1: Not all treatment effects are zero

DF	Chi-Square	P-Value
3	62.84	0.000

CONCLUSION/RECOMMENDATION

Through rigorous analysis and experimentation, the findings of this study indicate that the condition of the belt and the wheel play a pivotal role in influencing skewness. This conclusion was derived from both parametric and non-parametric statistical analyses, which further underscore the significance of these factors.