Automated Characterization of Hemispheric Resonator Gyroscopes

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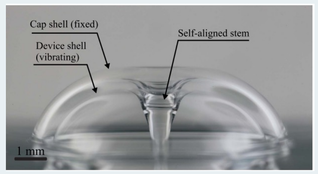
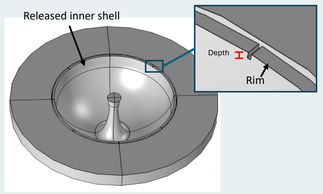
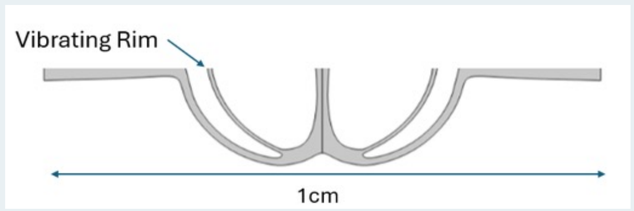
Executive Summary

The process of characterizing the vibrational modes of Hemispheric Resonator Gyroscopes (HRGs), such as finding the principal axis of elasticity and damping, is time-intensive and requires manual input. To reduce human involvement, we have developed a method of tracing the inner rim of the HRG with a measurement laser utilizing an image recognition machine learning algorithm. Automated controls collect the data for the trial, reducing the manual involvement to setting up the run.

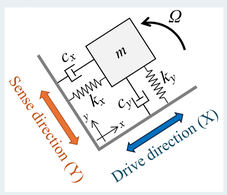
Context

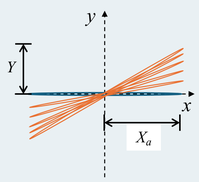




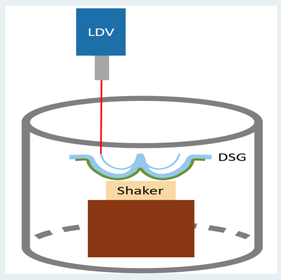


Gyroscope Operation



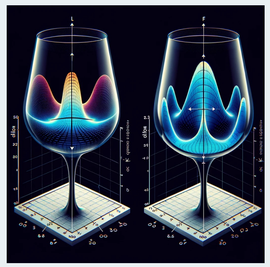


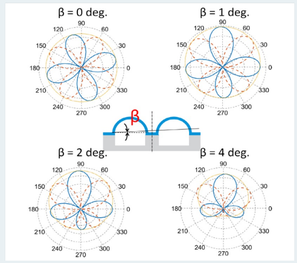
$$SF_{mech} = \frac{Y}{\Omega} = \frac{2A_g X_a \omega_x}{\sqrt{\left(\omega_y^2 - \omega_x^2\right)^2 + \left(\frac{\omega_x \omega_y}{Q_y}\right)^2}}$$



Laser Doppler Vibrometry (LDV) setup

Characterization Process

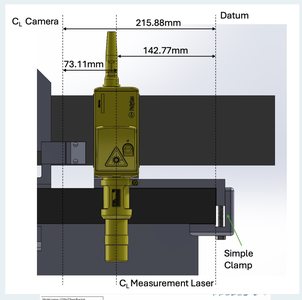


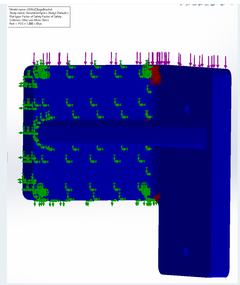


- Looking for Axes of Elasticity
- Wineglass Modes of Vibration

Mount (accomplishes analysis)

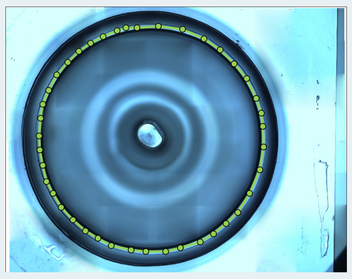
- Clamp to avoid damaging granite base
- Mount stays out of the way of the existing modules
- Avoids catastrophic vibrations
- Bracket accommodated loads exceeding a Safety Factor of 10+



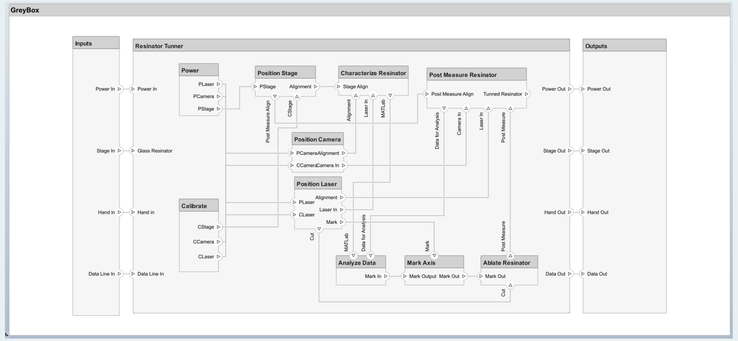


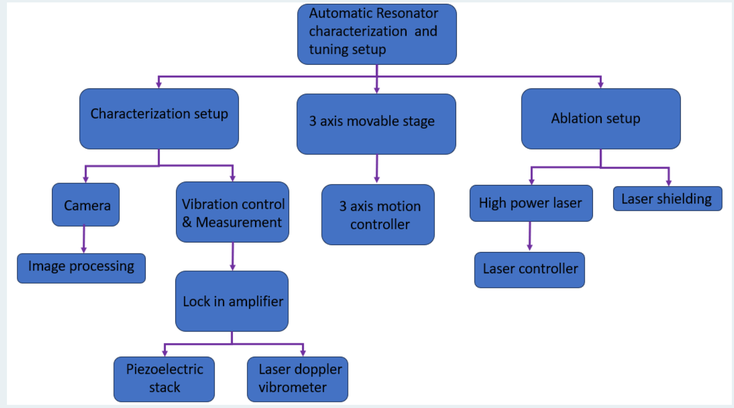
Computer Vision/ML

- MATLAB Image and Video Labeler Toolboxes
- Rim is not perfectly circular and varies with each HRG, causing traditional image processing techniques to fall short
- Machine Learning (ML) approach builds in greater tolerance for variation



Design Process





Future Work

Further work on this project will include integrating the characterization with laser ablation and FLICE stages. This will enable the automation of both the characterization and tuning phases of HRG manufacturing.

Acknowledgments

1. Microsystems Laboratory
2. Lois Meira
3. Prof. Mark Walter
4. Prof. David Copp