JOINT INSTITUTE
交大密西根学院

Analysis of Vibration-Induced Measurement Inaccuracies in Riveting Processes

Design Review #2

Group 24: Mansur Ayazbayev, Jingtian Zhu, Yiming Wang, Heng Zhao, Yujia Gao
Sponsor: Shanghai Systence Electronics Co.,Ltd
Section Instructor: Prof. Peisen Huang

SJTU

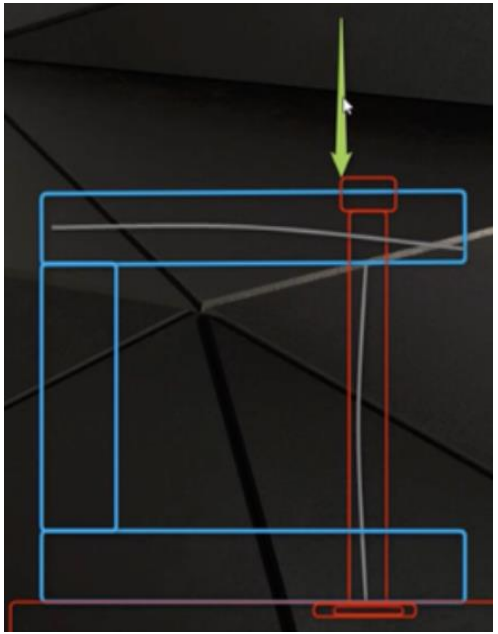
CONTENTS

Problem

Vibrations serve as a major cause of inaccurate riveting results even when using data-driven manufacturing equipment due to factors such as shifted reference height.

Example: Shanghai Systence had an issue with multinational client when riveting equipment was producing inaccurate rivets which lead to a lose of money, time and communication problems.

Products FMW Friedrich [1]



[1] Products FMW Friedrich. Available at: https://www.fmw-friedrich.de/en/products/riveting-machines-and-riveting-units.html (Accessed: 11 June 2024).

Goals

A system that can collect vibration data of the riveted part during the riveting process, analyze it, identify anomaly behavior, and give suggestions on how to eliminate those.

This can be achieved by simultaneously working on those sub-projects:

- **Sensor –** data collection;
- **Vibrations theory –** interpretation of the vibration anomaly behavior and its' solution;
- **Software –** creating UI application to automate and make data analysis more user-friendly;

Goal Image [1]

[1] Free Goals Clipart Transparent. Available at: https://clipart-library.com/free/goals-clipart-transparent.html (Accessed: 29 June 2024).

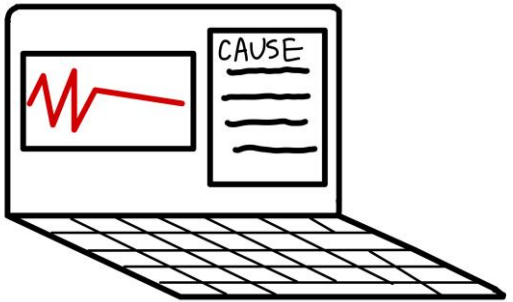
Final Project Sketch

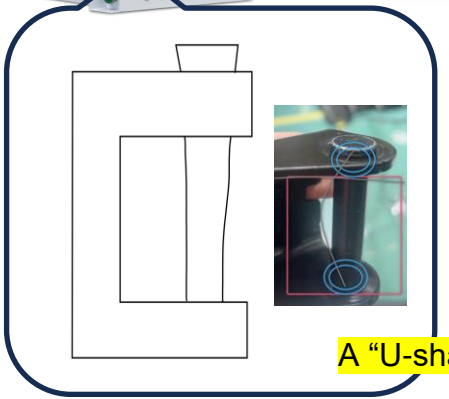
Riveting Machine [1]

Sensor [2]

Arduino board [3]

PC User Interface

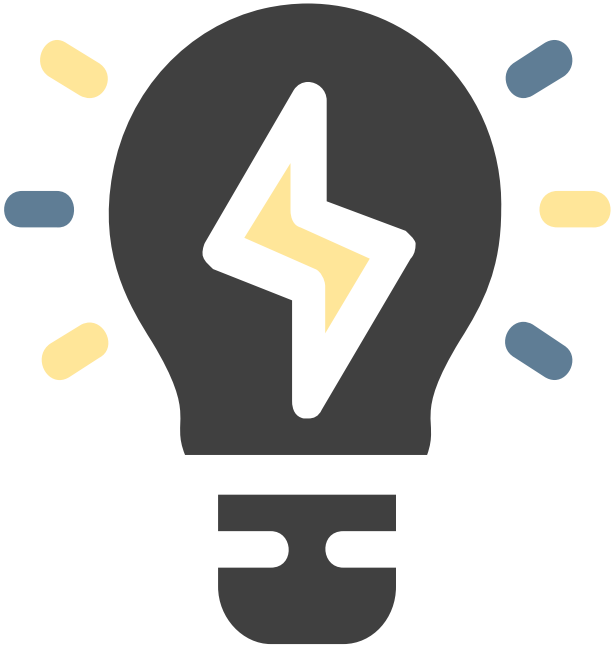




A “U-shaped” part

- Visualize the vibration
- If not the desired pattern, identify the cause of the vibration

[1]. Products FMW Friedrich. Available at: https://www.fmw-friedrich.de/en/products/riveting-machines-and-riveting-units.html (Accessed: 11 June 2024).
[2]. Keyence Laser Sensor, https://www.keyence.co.uk/products/sensor/positioning/il/
[3]. Arduino Uno REV3, Available at Amazon. (Accessed 29 June 2024)



Idea Image [1]

Updates Since DR1

Technical

- Narrowed down only studying one type of riveting parts.
- Added more engineering specifications during the concept selection stage.

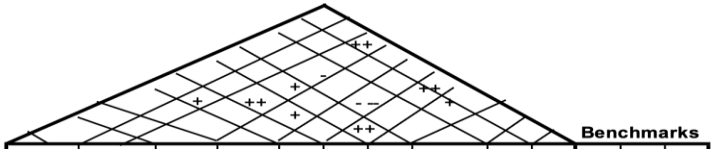
Technical Communication

- Started holding weekly meetings with the sponsor.

[1] Creative and Production Design. Available at: https://tcs.ink/creative-production-design/ (Accessed: 29 June 2024).

Requirements & Specifications

- Sensor
- Software
- Vibrations Theory



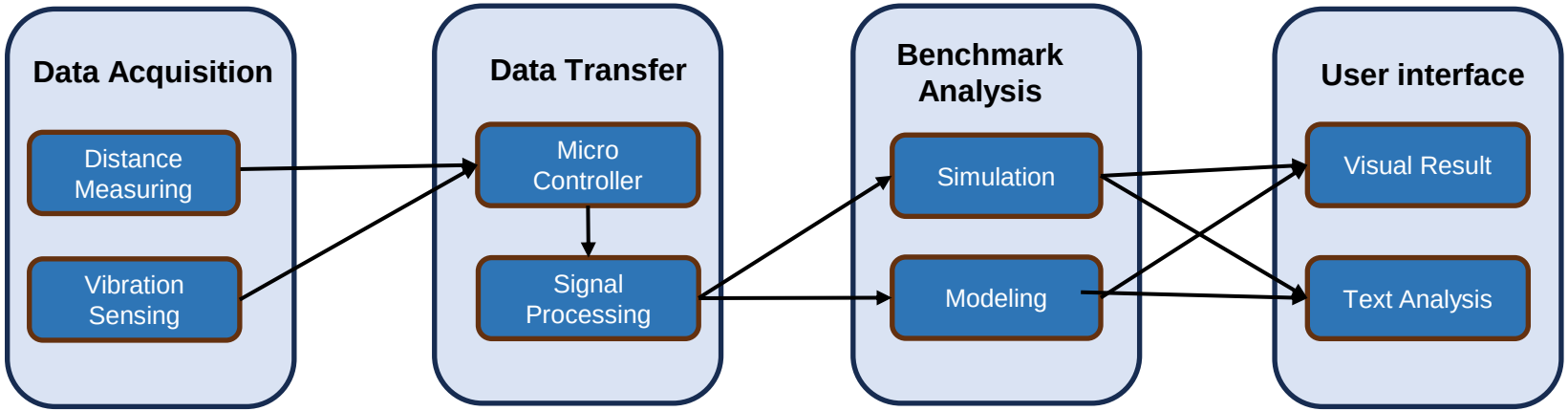
	Weight (1-10)	mass	volume	price	system's processing time	sensor's resolution	sensor's Repeatability	sensor's response time	sensor's frequency response range	sensor's error range	sensor's success rate	Benchmarks: m+p Analyzer	VibrationData Toolbox enDAQ	Dplot
Accurate vibration capture	10			1		9	9		9	9	9	5	5	/
Easy-to-use	9				9		1	3			1	5	2	3
Stable (long-distance transport)	9	3	3	3								5	4	5
Accurate vibration analysis	8				3	3	3		9	3	3	5	5	4
Fast	8			1	9			9				5	4	4
Portable	8	9	9									1	2	/
Easy-to-install	4	3	3	3								5	2	1
Cheap	3	3	3	9		3	1	9	3	3	1	1	3	5
Less parts needed	2	3	3	1								4	2	/
Appealing design	2	1	1									3	3	4
Measurement Unit		g	cm^3	RMB	ms	um	um	ms	Hz	%	%			
Target Value		1000	8000	4000	2000	1	±1	10	0-1000	±1	70			
Total		128	128	86	177	123	126	126	171	123	126			
Normalized		0,10	0,10	0,07	0,13	0,09	0,10	0,10	0,13	0,09	0,10			

Notes:

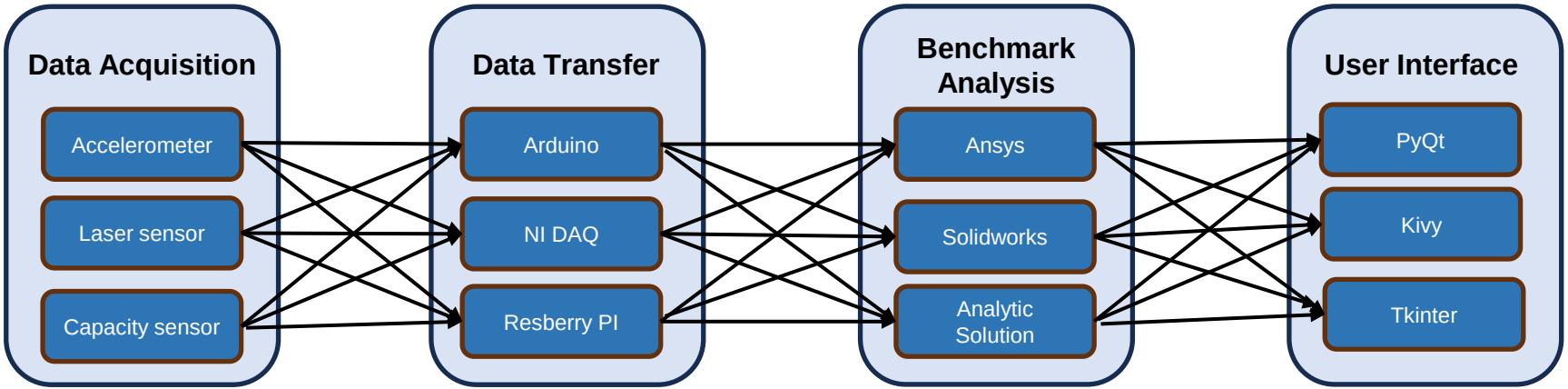
Vibrations Theory – used as a way for us to identify vibration issues nature and find reference values

Vibration engineering properties were eliminated based on the feedback from the academic faculty.

Morphological Analysis Conceptual Diagram



Morphological Analysis Potential Path



Sensors

[1]. MEMS Accelerometer

[2]. Laser Displacement Sensor

[3]. Capacity Sensor

Design Criterion	Weight factor	Unit	Accelerometer SG-MEMS-XYZ-V1			Laser Displacement sensor KEYENCE IL-S030			Capacity sensor enDAQ S3-D16		
			Value	Score	Rating	Value	Score	Rating	Value	Score	Rating
Price	0.2	RMB	950	10	2	2500	7	1.4	7000	1	0.2
Mass	0.11	g	50	9	0.99	60	8	0.88	16	10	1.1
Volume	0.1	mm^3	18900	10	1	36719	8	0.8	34061	8	0.8
Resolution	0.14	um	1.5	7	0.98	1	10	1.4	0.1	10	1.4
Repeatability	0.11	um	1	10	1.1	1	10	1.1	1	10	1.1
Sampling Rate/ Period	0.13	ms	0.04	10	1.3	0.33	9	1.17	0.31	9	1.17
Frequency Response Range	0.1	kHz/mm	6	6	0.6	30	9	0.9	32	9	0.9
Error Range	0.11	%	2	4	0.44	0.1	9	0.99	0.1	9	0.99
Total	1				8.41			8.64			7.66

[1]. Accelerometer SG-MEMS-XYZ-V1, “Three-axis MEMS Accelerometer Manual,” Sange-cbm.
[2]. Keyence Laser Sensor, https://www.keyence.co.uk/products/sensor/positioning/il/
[3]. enDAQ, Available at enDAQ official website, https://endaq.com/products/s3-vibration-sensor-s3-d16.

Micro-controller

NI DAQ

[1]. Arduino

[2]. Resberry Pi

Design Criterion	Weight factor	Unit	NI DAQ			Arduino			Resberry Pi		
			Value	Score	Rating	Value	Score	Rating	Value	Score	Rating
Price	0.28	RMB	3500	2	0.56	150	10	2.78	600	6	1.67
Mass	0.06	g	500	7	0.39	25	9	0.50	45	8	0.44
Volume	0.11	cm^3	2000	5	0.56	35	8	0.89	80	7	0.78
Clock speed	0.11	MHz	200	8	0.89	16	8	0.89	1500	9	1.00
I/O Interface	0.22	1-5	4	8	1.78	4	8	1.78	5	8	1.78
Ease-of-use	0.22	1-5	3	6	1.33	5	9	2.00	4	7	1.56
Total	1.00				5.50			8.83			7.22

[1]. Arduino Uno REV3, Available at Amazon. (Accessed 29 June 2024).
[2]. Resberry Pi, 2 Model B Desktop, Available at Amazon, https://www.amazon.com/Raspberry-Pi-Model-Desktop-Linux/dp/B00T2U7R7I?th=1

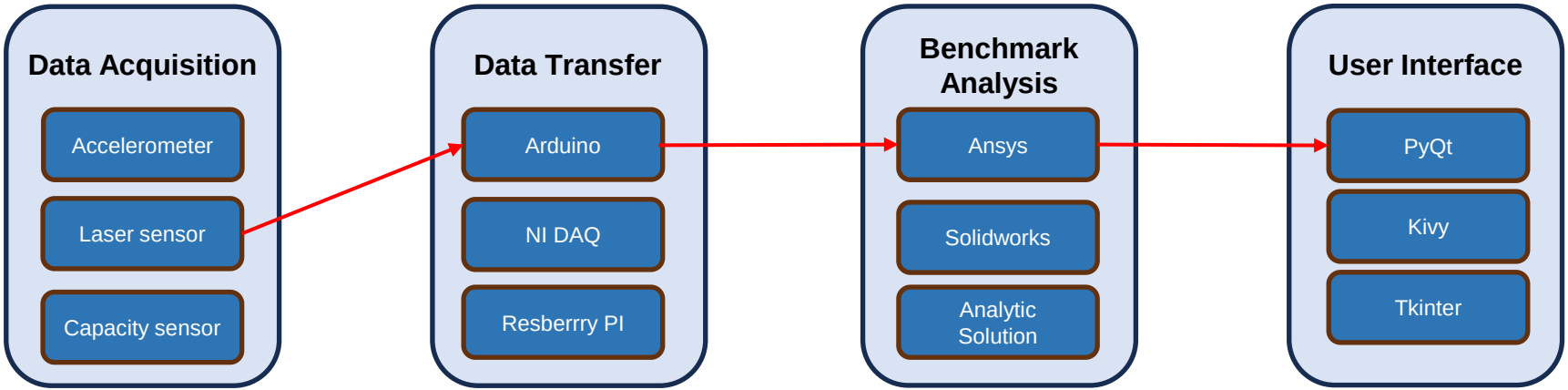
Vibration Analysis Theory

Design Criterion	Weight factor	Unit	Theory (Analytical Solution)			SolidWorks			Ansys		
			Value	Score	Rating	Value	Score	Rating	Value	Score	Rating
Model Geometry Accuracy	0.2	mm	5	2	0.4	0.5	8	1.6	0.05	9	1.8
Material Properties	0.1	%	14	5	0.5	8	8	0.8	3	9	0.9
Ease of Implementation	0.1	#	5	8	0.8	4	6	0.6	3	4	0.4
Post-Processing & Visualization	0.15	#	2	4	0.6	4	7	1.05	5	9	1.35
Frequency Analysis	0.15	%	7	4	0.6	2	8	1.2	0.4	9	1.35
Automation	0.2	#	2	4	0.8	4	9	1.8	4	9	1.8
Cost	0.1	RMB	0	10	1	10500	6	0.6	105000	3	0.3
Total	1				4.7			7.65			7.9

User Interface

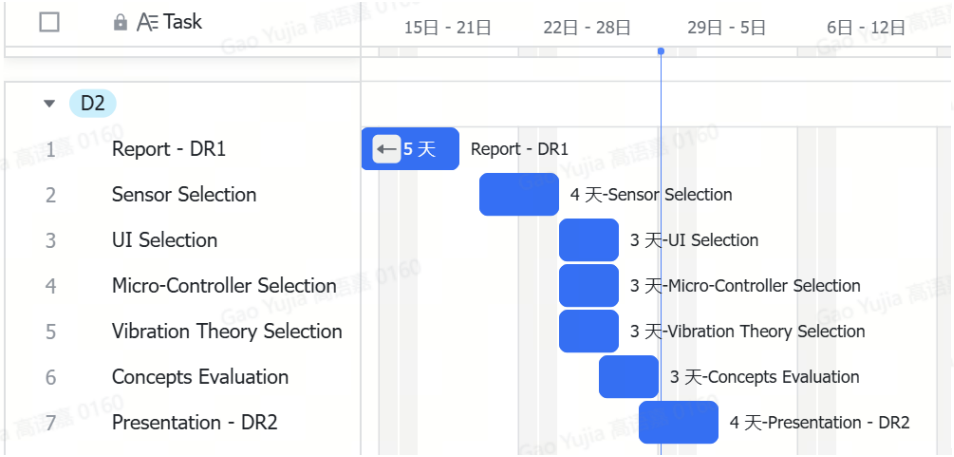
Design Criterion	Weight factor	Unit	tkinter			PyQt			Kivy		
			Value	Score	Rating	Value	Score	Rating	Value	Score	Rating
Learning Curve	0.14	h	20	10	1.43	50	7	1.00	40	8	1.14
Development Speed	0.21	h	30	9	1.93	70	7	1.50	60	8	1.71
Community Support	0.18	1-5	4	8	1.43	5	10	1.79	3	6	1.07
Response time	0.36	ms	100	6	2.14	50	10	3.57	70	7	2.50
Cross-platform Support	0.11	#	3	6	0.64	4	8	0.86	5	10	1.07
Total	1.00				7.57			8.71			7.50

Morphological Analysis Final Path



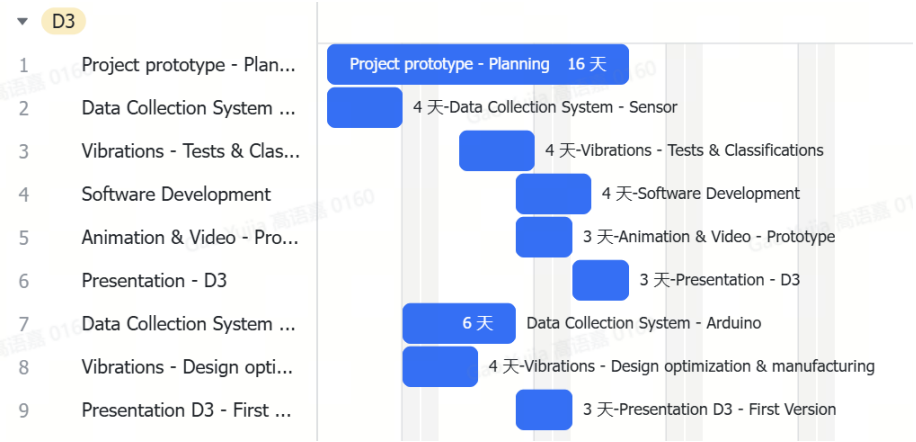
Schedule

Progress made since DR#1



- Finalized the Project Scope
- Selected concepts based on the new scope for sensor, micro-controller, vibration analysis method, and programming framework for user interface, and vibration theory
- Identified target commercial product to purchase.

Tasks after DR#2



- Setup the experimental structure
- Conduct vibration data collection
- Parallelly carry out vibration analysis, writing micro-controller codes, and user interface development
- Conduct repeated and controlled experiments to match each vibration pattern with a specific cause of vibration

Conclusion

Narrowed the study range

- Focusing on the “U-shaped” part
- Can match the vibration pattern with the cause.

Added new engineering specifications

- Offered more insights while selecting the concepts.

Generated and selected concepts

- Sensors: MEMS, laser, capacity.
- Vibrations Theory: Analytical Solution, SolidWorks, Ansys.
- Micro-controller: NI DAQ, Arduino, Resberry Pi.
- User Interface: tkinter, PyQt, Kivy.

Reviewed our progress and made sure we were right on schedule

JOINT INSTITUTE
交大密西根学院

Thank You for Your Attention!

Q&A