Using Machine Learning to Perform Force Calibration of Soft Triaxial Magnetic Sensors and Identify the Temperature of grasped objects

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His research interests are machine learning, development, and application of force sensors and three-claw robotic fingers.

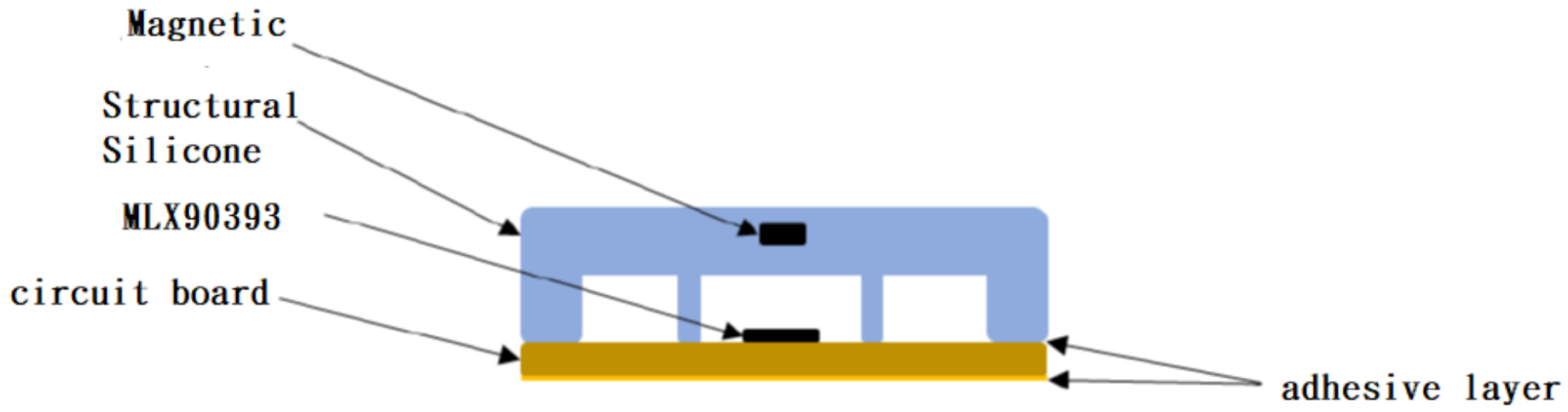
1. Introduction

We aimed at:

1. Accurately measure normal force and shear force
2. Accuracy less than 0.1N
3. Identify temperature of touched items

2.Sensor Architecture

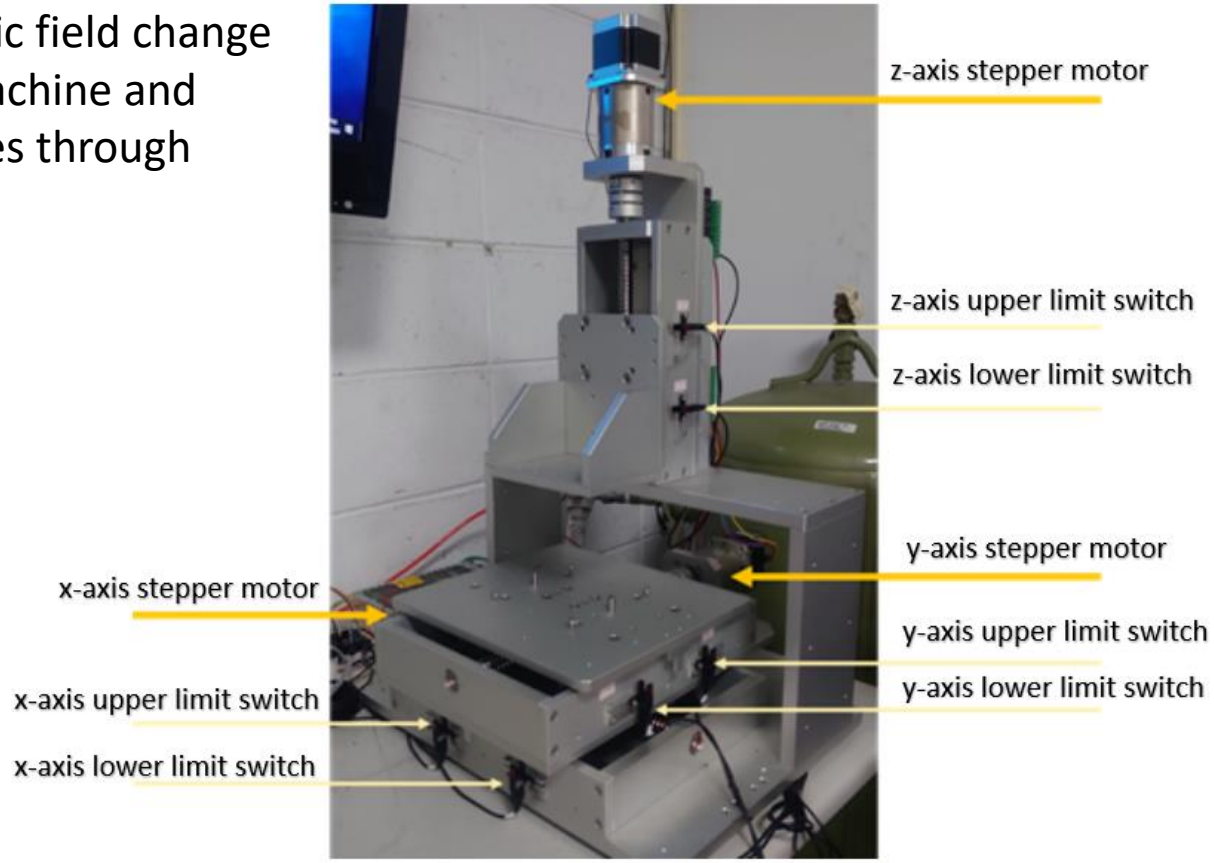
- Flexible circuit board
- Silicone structure
- Magnetic



3.Auto Calibration Machine

The 3D forces value and the magnitude of the magnetic field change can be obtained by using this automatic calibration machine and then the magnetic field can be converted into 3D forces through subsequent processing.

Size(mm*mm)	100*100
X-axis(mm)	±50
Y-axis(mm)	±50
Z-axis(mm)	50
Max of Normal force(N)	900
Resolution(N)	0.1
Max of Shear force(N)	500
Resolution(N)	0.1



4.Machine Learning Models

- Data format

  $(R_x, R_y, R_z, T) \rightarrow (F_x, F_y, F_z)$

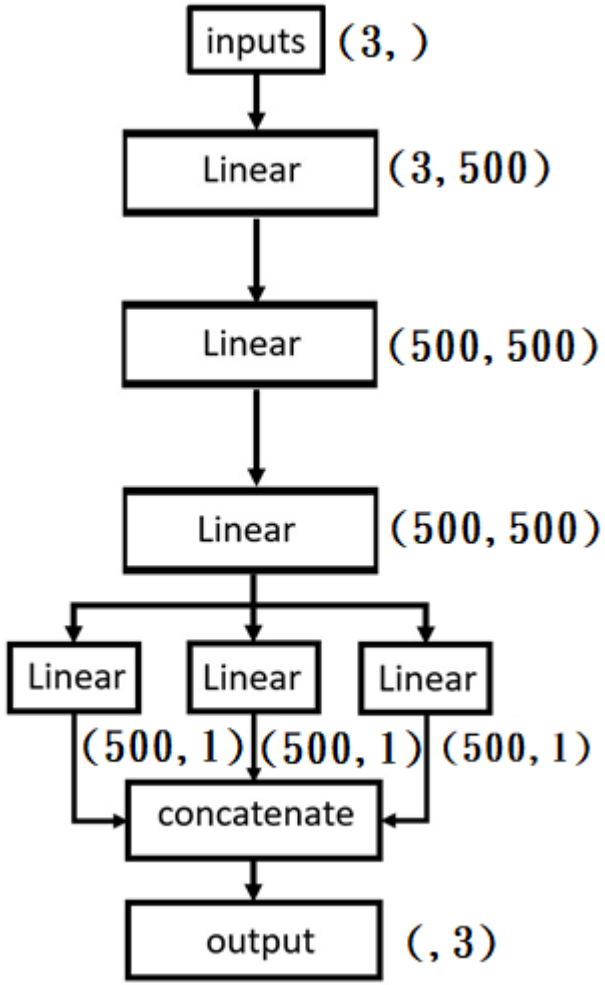
- Data processing

  need to normalize

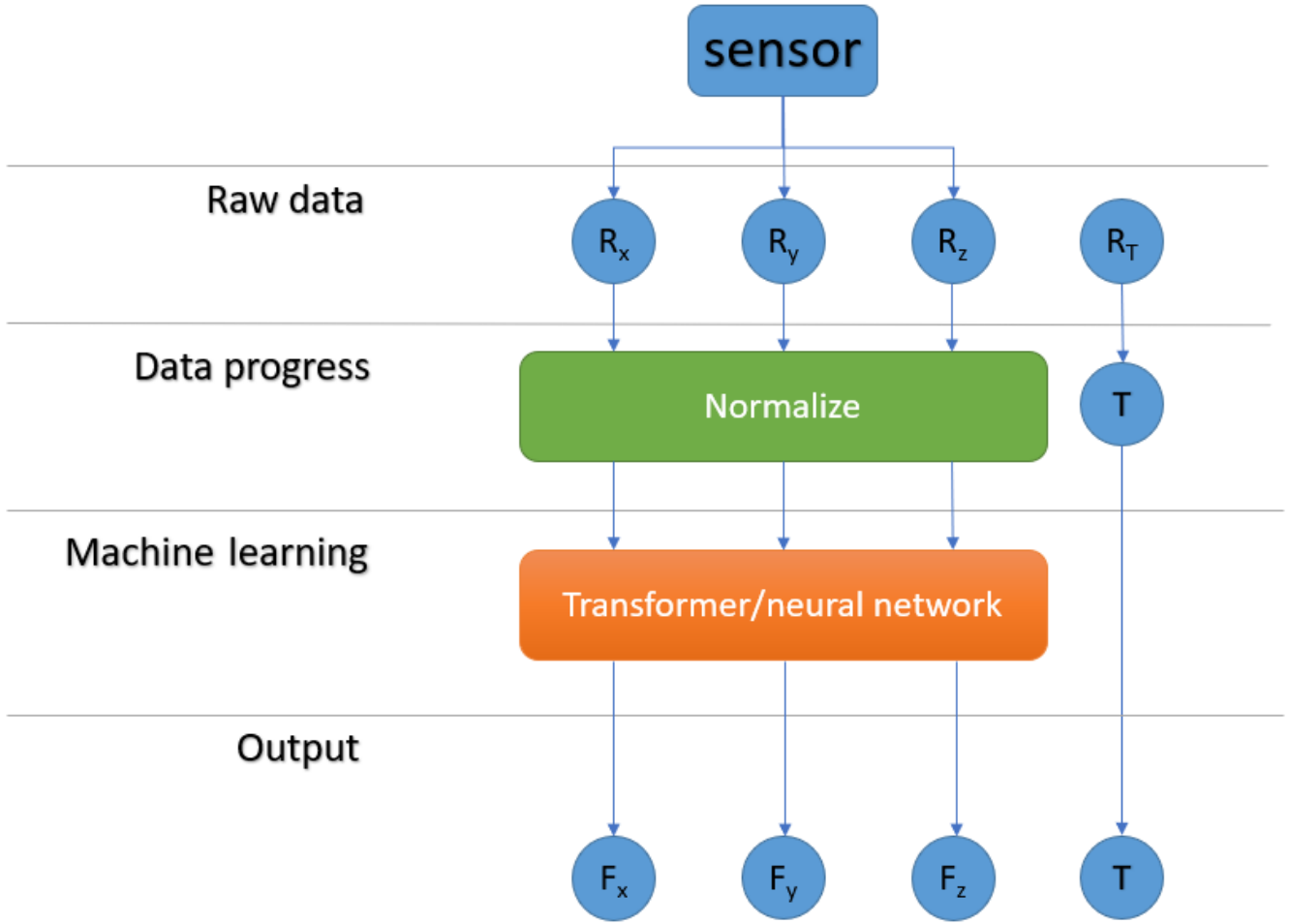
- Neural Networks

  ->ReLU、Tanh、Linear

  ->BatchNorm1d

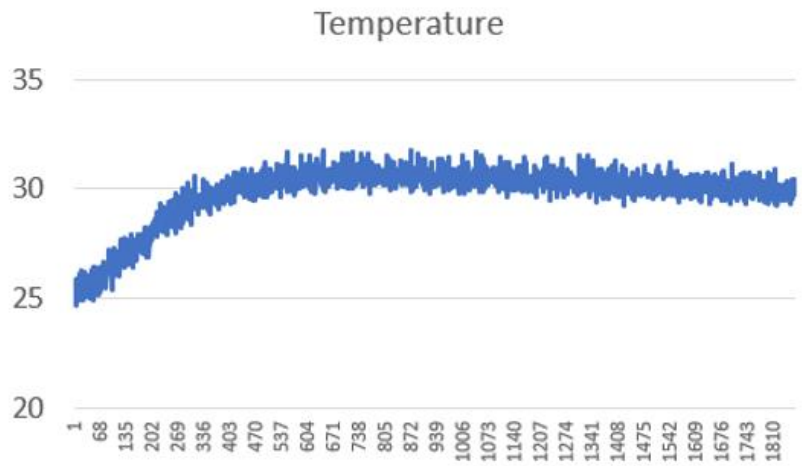


5.Experient


sensor
Raw data
R_x
R_y
R_z
R_T
Data progress
Normalize
T
Machine learning
Transformer/neural network
Output
F_x
F_y
F_z
T

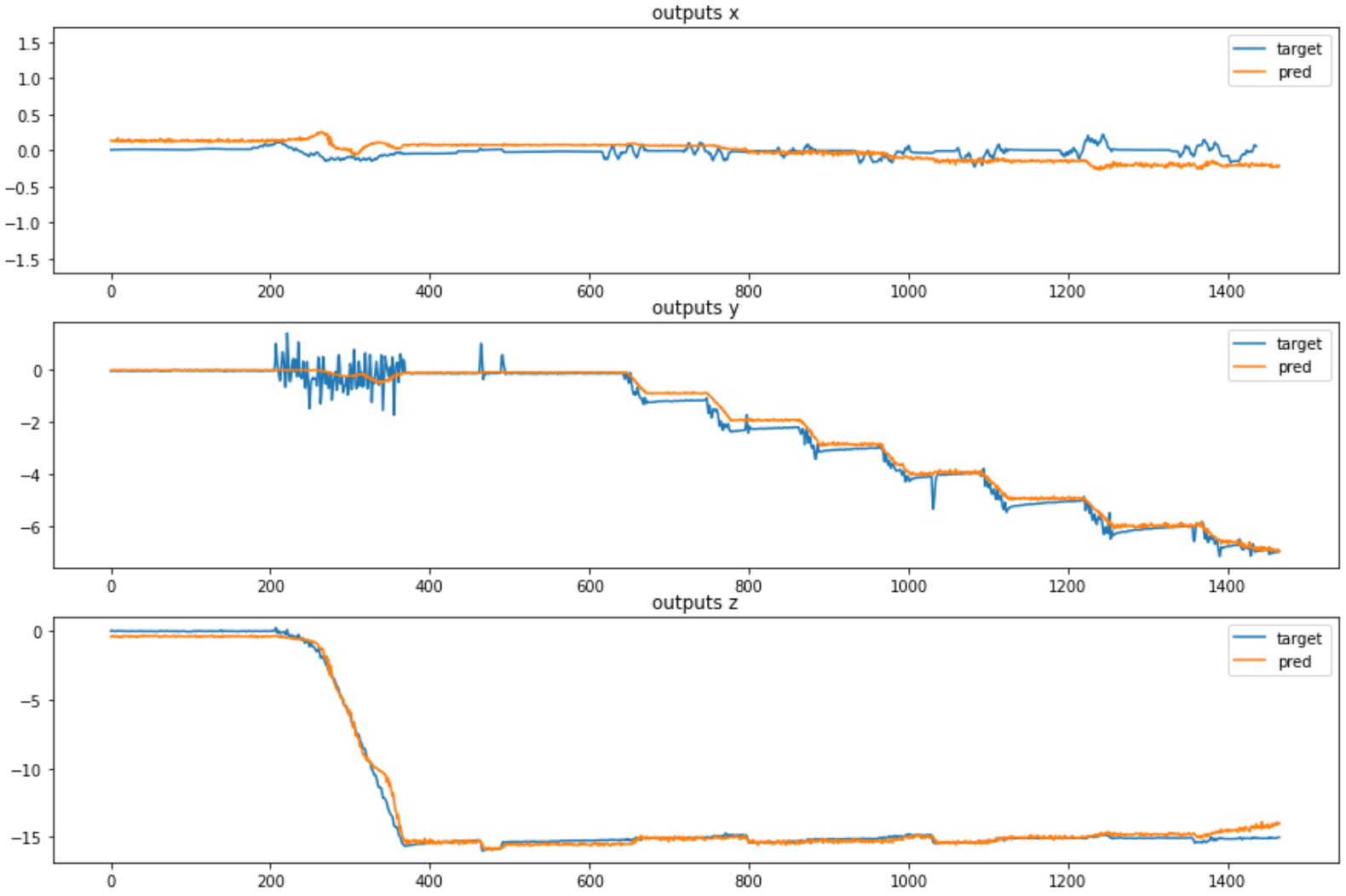
5.1 Temperature recognition

Comparison of sensor heating temperature and infrared thermal imager.



5.2 Sensor calibration

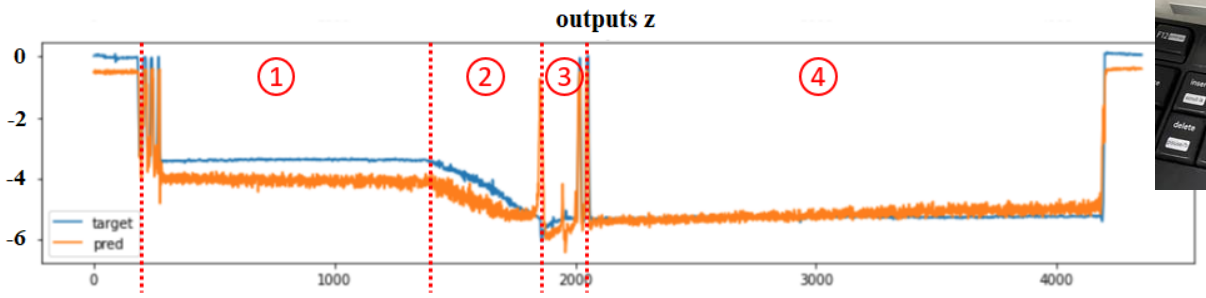
Schematic diagram of automatic calibration machine pressure test

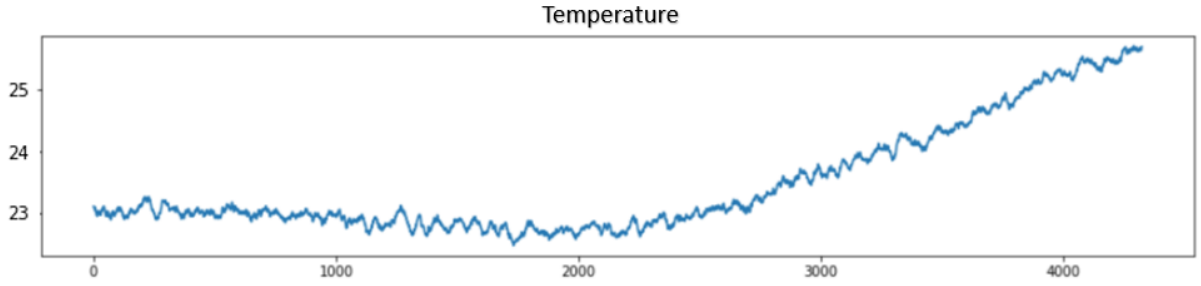


NEURAL NETWORKS AND TRANSFORMER WITH OR WITHOUT TEMPERATURE COMPENSATED RMSE AND MAE

type	RMSE	MAE
NN	1.39	1.1
Transformer	0.33	0.22

5.3 Temperature Identification Test





6. Conclusion

- The maximum normal force can be measured up to 30(N)
- The maximum shear force can be measured up to 10(N)
- It can measure temperature what it touched.

Future work:

1. design a sensor that can recognize the position of multiple points on this sensing surface
2. improve the application range of 3D force

Reference

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