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

Yao-Wei Tian, Jung-Tang Huang

Engineering of National Taipei University of Technology (Taiwan)
Contact email: t109408014@ntut.edu.tw
Yao-Wei Tian

Yao-Wei Tian is currently a master's student at the National Taipei University of Technology.

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (mm(^2))</td>
<td>100*100</td>
</tr>
<tr>
<td>X-axis (mm)</td>
<td>±50</td>
</tr>
<tr>
<td>Y-axis (mm)</td>
<td>±50</td>
</tr>
<tr>
<td>Z-axis (mm)</td>
<td>50</td>
</tr>
<tr>
<td>Max of Normal force (N)</td>
<td>900</td>
</tr>
<tr>
<td>Resolution (N)</td>
<td>0.1</td>
</tr>
<tr>
<td>Max of Shear force (N)</td>
<td>500</td>
</tr>
<tr>
<td>Resolution (N)</td>
<td>0.1</td>
</tr>
</tbody>
</table>
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
  \(
  \rightarrow \text{ReLU, Tanh, Linear}
  \rightarrow \text{BatchNorm1d}
  \)
5. Experiment
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

<table>
<thead>
<tr>
<th>type</th>
<th>RMSE</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NN</td>
<td>1.39</td>
<td>1.1</td>
</tr>
<tr>
<td>Transformer</td>
<td>0.33</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Neural Networks and Transformer with or without temperature compensated RMSE and MAE
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


