Deep Learning Wavelet Transform Techniques for Gaussian Linear Error Reduction in Cost-Effective Thermocouple Devices

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| **Article Info** |  | **ABSTRACT** (10 PT) |
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1. **INTRODUCTION (10 PT)**

Temperature merupakan salah satu parameter fundamental yang luas digunakan, dari mulai bidang industry, manufaktur, lingkungan hingga kesehatan. Luasnya penggunaan parameter tersebut menyebabkan peningkatan permintaan terhadap instrument pengukuran suhu akurat semakin meningkat, hal ini didukung oleh data yang diperoleh dari pasar global memperkirakan annual growth dari sensor temperature akan meningkat sebesar 4.8% pada tahun 2027 [1], serta diperkirakan bahwa market dari sensor akan melebihi angka 10 billion sensors/year pada 10 tahun kedepan [2]. Dampak yang disebabkan akibat meningkatnya permintaan adalah menignkatnya harga sensors dengan akurasi tinggi yang diakikabtkan oleh ketersediaan barang di pasar yang masih rendah. Hal ini berimbas pada peningkatan penggunaan sensor murah dengan kualitas akurasi rendah.

Tingkat akurasi serta jangkauan pembacaan sensor temperature dipengaruhi oleh tipe sensor temperature yang digunakan, penggunaan sensor thermocouple seringkali digunakan karena kemampuan jarak jangkauan pembacaan nya yang tinggi serta harganya yang murah, ketimbang thermistor yang memiliki sustepbilitas terhadap panas yang rendah serta resistance temperature detector (RTD) yang memiliki harga tinggi [3]. Permasalahan utama yang terdapat pada sensor thermocouples adalah keberadaan johnson noise yang tercipta akibat thermal gradients pada reference junctions [4] yang disebabkan akibat buruknya insulasi, shielding dan stabilisasi temperature pada perangkat elektronik thermocouple, yang menyebabkan terdapatnya noise thermal pada pembacaan. Selain noise yang tercipta pada sensor thermocouple, noise lain yang tercipta akibat electromagnetic interference interference pada elektronik sirkuit serta tegangan input yang tidak stabil akibat keberadaan ripple atau grounding yang buruk mempengaruhi kualitas pembacaan yang dihasilkan [5].

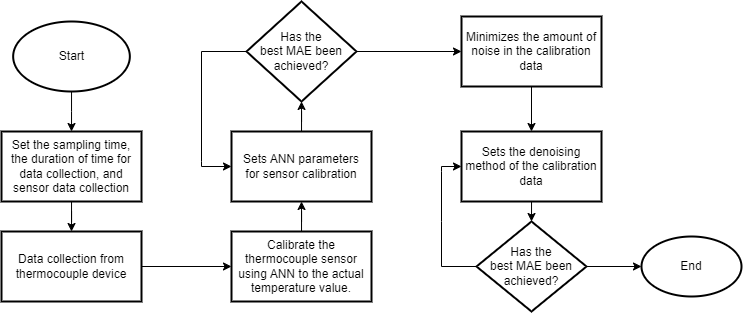
Dalam meminimalisir keberadaan noise tersebut beberapa pendekatan telah dilakukan salah satunya adalah menerapkan algoritma kalman filter pada proses denoising [6], akan tetapi proses penerapan kalman filter ini terlalu bergantung pada system dynamic model yang ditetapkan di awal serta tidak efektif pada data yang memiliki variasi tinggi [7], pendekatan menggunakan deep neural network juga telah dilakukan untuk meminimalisir jumlah noise yang terdapat pada data thermocouple dan di dapatkan nilai root mean squared error (RMSE) sebesar [8] namun keberadaan noise masih terlihat pada area peak signal, penggunaan fast fourier transform (FFT) dalam proses denoising berdasarkan nilai frekuensi yang di observasi [9], akan tetapi proses denoising menggunakan fourier transform terdapat limitasi yakni limitasi dalam menghadapi transient noise dan frequency leakage yang umum terjadi pada non-stationary signals seperti pembacaan data sensor. Tingginya besar fluktuasi dan noise yang ditimbulkan pada sensor thermocouple menyebabkan teknik data akuisisi konvensial menjadi tidak akurat dan tidak dapat digunakan.

Dalam mengatasi permasalahan tersebut, penelitian ini dilakukan untuk meningkatkan kualitas pembacaan dari sensor thermocouple dengan menggunakan algoritma deep neural network yang dikombinasikan dengan penggunaan wavelet transform (WT) sebagai metode denoising signal pembacaan, melalui kedua teknik tersebut nilai mean absolute error (MAE) serta signal to noise ratio (SNR) akan digunakan sebagai metrics evaluasi dari performa teknik tersebut pada pembacaan suhu temperature menggunakan sensor thermocouple.

1. **METHOD**

Pengukuran temperature menggunakan sensor thermocouple sering kali memiliki akurasi dan presisi yang rendah serta noise yang tinggi yang diakibatkan oleh noise pada reference junction, shielding dan insulasi yang buruk, tegangan input yang tidak stabil serta pengaruh electromagnetic interference pada modul perangkat yang menyebabkan reabilitas dan kualitas data menggunakan metode konvensional memiliki akurasi serta presisi yang rendah. Tingkat reabilitas data berbanding terbalik terhadap tingkat noise yang dimilkiki, semakin rendah besar deviasi maka semakin tinggi tingkat reabilitas data.

Penelitian ini bertujuan untuk meningkatkan kualitas dan reabilitas data menggunakan WT untuk mengetahui pengurangan noise serta meningkatkan signal-noise-ratio (SNR) dari sinyal input dengan menggunakan metode kalibrasi berbasis ANN dengan memvariasikan fungsi aktivasi untuk mengetahi MAE terendah dari variasi fungsi aktivasi yang diberikan. Penelitian dilakukan dengan



**2.2. Artificial Neural Network (ANN)**

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|  | | (1) |
|  | | (2) |
| L | : Layer | |
| k | : Node input | |
| K | : Total Node input | |
| j | : Node output | |
|  | : Activation Functions | |
|  | | **(3)** |
|  | | **(4)** |
|  | | **(5)** |

**Gaussian activation**

**2.3. Wavelet Transform**

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|  | | **(1)** |
|  | : Layer | |
|  | : Node input | |
|  | : Total Node input | |

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|  | |  |
| **L** | **: Layer** | |
| **k** | **: Node input** | |
| **K** | **: Total Node input** | |
| **j** | **: Node output** | |
|  | **: Activation Functions** | |

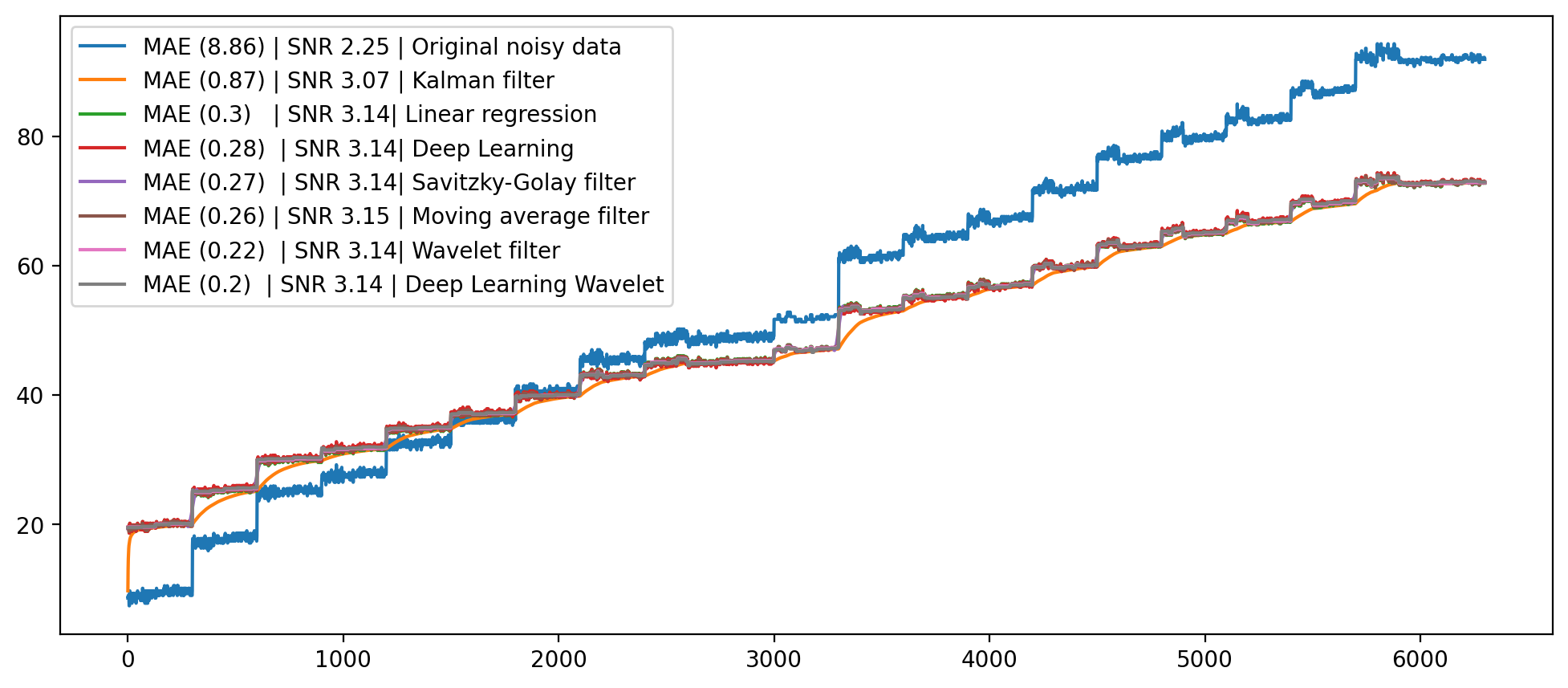
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|  | | **(1)** |
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| **L** | **: Layer** | |
| **k** | **: Node input** | |
| **K** | **: Total Node input** | |
| **j** | **: Node output** | |
|  | **: Activation Functions** | |

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|  | | **(1)** |
|  | | **(2)** |
| **L** | **: Layer** | |
| **k** | **: Node input** | |
| **K** | **: Total Node input** | |
| **j** | **: Node output** | |
|  | **: Activation Functions** | |

1. **RESULTS AND DISCUSSION**

A group of graphs showing different types of data

Description automatically generated



1. **CONCLUSION**

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**BIOGRAPHIES OF AUTHORS (10 PT)**

**The recommended number of authors is at least 2. One of them as a corresponding author.**

*Please attach clear photo (3x4 cm) and vita. Example of biographies of authors (9 pt):*

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