

**Klasifikasi Aktivitas Manusia Berdasarkan
Amplitudo Channel State Information (CSI) Berbasis Wi-Fi Sensing
dengan Recurrent Spiking Neural Network (RSNN)**

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INTISARI

Pengenalan aktivitas manusia (*Human Activity Recognition / HAR*) berbasis Wi-Fi *sensing* merupakan pendekatan non-invasif (menjaga privasi) dan *device-free* dengan memanfaatkan perubahan propagasi sinyal nirkabel. Informasi utama yang digunakan adalah *Channel State Information (CSI)*, yang mampu merepresentasikan dinamika lingkungan secara detail. Namun, sistem HAR berbasis CSI masih menghadapi tantangan dalam mencapai keseimbangan antara performa klasifikasi dan efisiensi komputasi.

Penelitian ini bertujuan untuk mengklasifikasikan aktivitas manusia menggunakan amplitudo CSI dengan model *Spiking Neural Network (SNN)* dan *Recurrent Spiking Neural Network (RSNN)*. Data CSI dikumpulkan menggunakan NIC Intel AX210 dengan *bandwidth* 80 MHz untuk lima kelas aktivitas (tidak ada orang, berdiri, duduk, berjalan, berlari). Tahapan praproses meliputi ekstraksi amplitudo CSI, segmentasi *sliding window*, dan normalisasi data (*Z-score*). Kinerja SNN dan RSNN dibandingkan dengan model *Recurrent Neural Network (RNN)*, serta dianalisis pengaruh inisialisasi bobot Xavier.

Hasil penelitian menunjukkan bahwa RSNN mencapai performa terbaik dengan nilai akurasi 97,30% (*F1-Score* 0,9794), diikuti oleh RNN (90,03%) dan SNN (81,67%). Meskipun jumlah parameter RSNN besar ($\pm 2,13$ juta), waktu inferensi RSNN (4,37 s) lebih cepat dibanding SNN (5,36 s). RNN tercatat memiliki kompleksitas komputasi terbaik dengan jumlah parameter 260.805 dan waktu latihan ± 221 detik. Dampak inisialisasi Xavier meningkatkan akurasi SNN (+7,01%), relatif netral untuk RNN, dan menurunkan performa RSNN (akurasi -2,42%). Ditemukan juga bahwa penggunaan inisialisasi Xavier tidak mengubah kompleksitas komputasi (jumlah parameter tetap sama).

Kata kunci: Wi-Fi Sensing, Channel State Information, Pengenalan Aktivitas Manusia, Spiking Neural Network, Recurrent Spiking Neural Network

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Human Activity Recognition (HAR) Based on Wi-Fi Sensing Channel State Information (CSI) Amplitude with Recurrent Spiking Neural Network (RSNN)

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ABSTRACT

Human Activity Recognition (HAR) based on Wi-Fi sensing is a non-invasive and device-free approach that preserves user privacy by exploiting variations in wireless signal propagation. The primary information utilized in this approach is Channel State Information (CSI), which is capable of representing environmental dynamics in detail. However, CSI-based HAR systems still face challenges in achieving a balance between classification performance and computational efficiency.

This research aims to classify human activities using CSI amplitude data through Spiking Neural Network (SNN) and Recurrent Spiking Neural Network (RSNN) models. CSI data were collected using an Intel AX210 network interface card with an 80 MHz bandwidth for five activity classes: no person, standing, sitting, walking, and running. The preprocessing includes CSI amplitude extraction, sliding window segmentation, and data normalization using Z-score. The performance of SNN and RSNN was evaluated and compared with a conventional model (Recurrent Neural Network / RNN), and also analyzed based on the effect of Xavier weight initialization.

The results showed that RSNN achieved the best performance with an accuracy value of 97.30% (F1-Score 0.9794), followed by RNN (90.03%) and SNN (81.67%). Although the number of RSNN parameters is large (± 2.13 million), the inference time of RSNN (4.37 s) is faster than SNN (5.36 s). RNN was recorded as having the best computational complexity with the number of parameters 260,805 and training time ± 221 seconds. The impact of Xavier initialization increased the accuracy of SNN (+7.01%), was relatively neutral for RNN, and decreased the performance of RSNN (accuracy -2.42%). The use of Xavier initialization did not change the computational complexity (same number of parameters).

Keywords: Wi-Fi Sensing, Channel State Information, Human Activity Recognition, Spiking Neural Network, Recurrent Spiking Neural Network

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