Chapter 7
A Hybrid Approach for Smart Home Activity Recognition Using Sensor Data and Deep Learning Techniques

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ABSTRACT

Recognizing human activities in smart homes poses challenges due to environmental variability, sensor systems, and sparse signals. Deep learning models struggle to extract meaningful features autonomously, necessitating additional context. This study proposes a novel hybrid approach merging natural language processing and time series classification techniques to address feature extraction for activity recognition. Sensor events are encoded into frequency-based terms, generating embeddings capturing semantic relationships. Evaluation on two smart home data-

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sets demonstrates the effectiveness of encoding-based embeddings for improving automatic feature learning. Comparisons with Cascade LSTM and other models show the superiority of the proposed approach. The hybrid technique, centered around Cascade LSTM, effectively leverages contextual information from sensor event sequences for recognizing complex human activities in smart homes.

I. INTRODUCTION

Over the years, the methodology for recognizing human activities from sensor data in smart homes has evolved significantly. Initially, conventional machine learning approaches relying on handcrafted features were prevalent. However, these methods often struggled to capture the rich temporal dependencies present in sensor sequences. With the advent of deep learning, particularly recurrent neural networks (RNNs) like Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU), there was a paradigm shift towards models better suited for temporal data analysis. Additionally, convolutional neural networks (CNNs) were successfully applied by treating sensor sequences as images, paving the way for novel approaches in activity recognition. Despite these advancements, certain gaps remained prevalent in the field. Challenges persisted due to the variability in sensor readings, overlapping activities, and the lack of well-defined boundaries between activities. Moreover, traditional deep learning models often struggled with noise, sparsity, and irregular sampling of sensor data. These limitations underscored the need for innovative methodologies capable of addressing these challenges effectively. In response to these identified gaps, this paper introduces a novel hybrid approach that combines natural language processing and time series classification techniques to tackle the feature extraction problem in activity recognition. Central to our methodology is the encoding of sensor events into terms based on frequency, akin to text representations. This encoding process generates embeddings that capture semantic relationships between events, thus facilitating more effective feature learning. Furthermore, we identify and address the gap in leveraging domain knowledge within the model architecture. By incorporating a Cascade LSTM architecture, we capitalize on the temporal dependencies present in sensor sequences, enhancing the model's ability to capture complex activity patterns.