AI-Driven Human Behaviour Understanding for Healthcare

Applicant: Khuloud Halimeh

Field: Computer Vision, Human Action Recognition, AI for Healthcare

Proposed Program: PhD in Computer Science / Artificial Intelligence

1. Title

Graph and Multimodal Deep Learning for Human Action Recognition and Behavior Monitoring in Healthcare Applications

2. Abstract

This study presents an advanced Human Action Recognition (HAR) framework designed to enhance behavioral comprehension and health surveillance in practical healthcare environments. The project centers on skeleton-based modeling utilizing Graph Neural Networks (GNNs) and incorporates multimodal data sources, including RGB, depth, and sensor signals. The goal is to create systems that are easy to understand and use that can find unusual actions, changes in gait, and early signs of cognitive or mobility decline. The work builds on my Master's research on AGCN, CTR-GCN, and ShiftGCN. Its goal is to create hybrid graph–transformer models, multimodal fusion pipelines, and self-supervised learning methods that can be used in clinical and assistive settings.

3. Background & Problem Statement

Healthcare systems are using AI more and more to keep an eye on patients' behavior, find falls, keep track of rehabilitation, and spot early symptoms. HAR has a lot of potential, but there are problems with current systems: they don't work well across different subjects and environments, they are sensitive to noise when extracting skeletons, they don't work well with multiple modes, they are hard to understand, and they are limited by computing power. Graph Neural Networks have improved HAR, but they need to be changed to work well in clinical settings. This project fills these gaps by making HAR systems that are made just for healthcare settings.

4. Research Questions

1. How can hybrid graph-transformer models improve HAR in healthcare settings?
2. What strategies for combining multiple modes make action recognition more accurate?
3. Is it possible for self-supervised learning to lessen the need for assigned data in clinical environments?
4. How can clinicians and caregivers understand HAR models better?
5. What improvements make it possible to deploy in real time on edge and embedded devices?

5. Methodology

The project will use NTU RGB+D (skeleton, RGB, depth), Dem@Care (daily activities of the elderly), the UR Fall Detection Dataset, and any other clinical or lab datasets that are available. To set a baseline for performance, we will reimplement ST-GCN, AGCN, CTR-GCN, and ShiftGCN.

Proposed Model Innovations:

- Hybrid Graph–Transformer Models that use both spatial GNNs and temporal attention.
- Combining skeleton, RGB, depth, and sensor signals in different ways, like early, mid, and late fusion.
- Self-supervised learning methods like contrastive learning, masked modeling, and temporal prediction.
- Explainability tools like joint-importance heatmaps and temporal saliency.
- Improving deployment by pruning models, quantizing them, and speeding up edge devices.

6. Expected Contributions

- A new HAR model called a hybrid graph-transformer that works best for healthcare.
- An AI framework that uses more than one mode to watch how people act.
- Self-supervised learning methods that work with small healthcare datasets.
- Things that help explain clinical decision support.
- How to use HAR in real time on edge and wearable devices.
- Open-source code and benchmarks that can be used again and again.

7. Timeline (4 Years)

Year 1: Review of the literature, preparation of the dataset, and creation of baseline models.
Year 2: Create a hybrid graph-transformer HAR model and turn in the first paper.
Year 3: Multimodal fusion, self-supervised training, and evaluations of healthcare.
Year 4: Explainability, deployment, writing a dissertation, and publishing the final papers.

8. Conclusion

This study will enhance HAR via multimodal and graph-based methodologies specifically designed for clinical and healthcare contexts. This PhD aims to create useful AI systems for understanding behavior, caring for the elderly, monitoring rehabilitation, and finding health problems early on. It builds on my knowledge of GNNs and skeleton-based HAR.