Chapter 2: Literature Review

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The problem to be addressed in this study is implementing a quality assurance process for an autonomous assistant for elderly and special needs care. This research theorizes that using computer vision (CV) can provide a consistent experience across a diverse global audience. Building autonomous assistants is challenging due to requiring multiple domain specializations like computer networking, embedded technologies, AI/ML, and distributed computing (Tun, Madanian, & Mirza, 2021). Beyond technical constraints, potential privacy and safety from video monitoring create barriers to locating volunteer patients. Furthermore, those difficulties limit other researchers from reproducing the results. These factors slow down innovation and restrict the value researchers can contribute to the body of knowledge.

This constructive research design study aims to propose a research process that divorces privacy and safety concerns from investigating autonomous assistants in elderly and special needs care. It aims to deliver this capability by utilizing humanoid constructs within a realistic physics simulation process. Next, positioning virtual cameras, instruments, and devices within the virtual world enables researchers to collect their experimentation data. Lastly, the automation can modify the environment using programmable interfaces such as raising the alarm or applying other mitigations.

## Thematic overview

The study presumes that CV and HAR can improve the livelihood of elderly and special needs patients. However, implementing those custom models is prohibitively expensive, and any research conclusions will be challenging to reproduce. This research project aims to mitigate these challenges by demonstrating CV and HAR methodology with simulated humanoids. It is beyond the scope of this dissertation to prove those methods are superior to existing and more laborious strategies.

There are multiple core concepts necessary to delivering this outcome. First, the central premise relies on exhibiting CV and HAR methodologies. Computer vision (CV) is a process for extracting data from image sources. Next, human activity recognition (HAR) processes must classify that data into distinct actions and behaviors, such as the person is sitting or falling. Those requirements raise several questions within the literature review context. For example, what mechanisms are being built or deprecated? This research study does not aim to create a novel solution and plans to reuse existing methods.

Second, the research topic needs to train the ML model using a simulated environment with humanoid characters and virtual instruments. This situation raises implementation questions such as trade-offs between industry-standard tooling, design patterns, and configuration nuances. The literature review must identify strategies that are likely to produce high-quality results. It is beyond the scope of this dissertation to implement proof-of-concept (POC) solutions for every potential combination.

Third, the artifacts must be high-quality and functional within a noisy environment. Meeting these expectations raises questions regarding ML training strategies. For example, do other researchers remove (or add) randomness to their DNN architectures? Are there specific situations that are more applicable for improving model quality? This constructive research study aims to incorporate these recommendations but stops short of directly comparing algorithms or methods.

Fourth, the literature review must uncover strategies for scaling the ML training and inference to production scale. This sub-topic is crucial for bringing ML capabilities to public markets. However, it is also sufficiently complicated to populate multiple separate dissertations. Therefore, this dissertation only discusses literature trends for high-performance hardware, low-power hardware, and edge networks.

## Methods

This literature review used the Northcentral University Library (NCUL) to identify relevant peer-reviewed articles and books published from 2019 to 2022. It also includes foundational papers for historical context and generally accepted process standards outside this period. Students use NCUL’s Roadrunner search to aggregate results from industry-standard sources like the Institute of Electrical and Electronics Engineers (IEEE), Association for Computer Machinery (ACM), Springer Publishing, John Wiley & Sons ProQuest, among others.

A breath-first search scanned for surveys, challenges, and opportunities on the constructive research project’s core concepts (see Table 1). The breath-first search uncovered several themes that drove depth-first investigations. For instance, researchers are approaching hyper-scale ML training with custom hardware acceleration and continuous learning-at-the-edge methods (Plus Company Updates, 2021; Prapas et al., 2021). In other cases, themes like *Using Convolutional-Graph Neural Networks (C-GNN) for HAR* necessitate a sequential breadth-first search to contextualize supporting concepts. This search process continued until finding fifty unique documents. Next, bibliographical reviews for each document extracted themes. Those sorted themes are available in the proceeding conceptual frame section, which attempts to present each topic’s current state and direction from Table 1.

Table 1: Survey search terms

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| --- | --- |
| Concept | Example search queries |
| Elderly and special needs industry state | * (elderly care or special needs) and industry * (global or internal) and (disabled or medical) |
| Computer vision (CV) | * computer vision or CV * computer vision and (surveys or opportunities) |
| Human Activity Recognition (HAR) | * (human activity recognition or HAR) and (computer vision or CV) * HAR (state-of-the-art or challenges) |
| Machine Learning (ML) Training | * (ML or machine learning) training and scale * distributed ML training |
| Physics simulation | * (Unity or ROS or robotic operating system) and (process or environment) simulation * (dynamic or synthetic or virtual) environment testing |

## Conceptual Framework

A conceptual framework is a blueprint that communicates a natural progression of the phenomenon to be studied (Dickson, Emad, & Adu-Agyum, 2018). It is essential for quality research as it outlines a methodical structure of definitions, concepts, and relationships.

1. Describe the guiding conceptional framework, its definitions, concepts, and relationships
2. Explain the origin of the framework and its current state
3. Identify who used this framework and alternatives (pros/cons)
4. Describe how and why the selected framework relates to the problem, purpose, and research subjects.

## Challenges and opportunities for care providers

## Computer vision

## The Role of HAR

## Building simulation environments

## Training ML models at scale