

# Chapter 15

## Real–Time Data Analytics and Decision Making in Cyber–Physical Systems

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### ABSTRACT

*The future of digital innovation lies in Cyber-Physical Systems (CPS), integrating computational capabilities with physical processes. CPS function as interconnected networks, merging physical and digital inputs and outputs. This study defines CPS and highlights real-time data analytics' role in enhancing communication across industries like manufacturing and robotics. CPS depend on data collection via edge computing, IoT, and sensors, involving data cleaning, preparation, and normalization. Real-time analytics, including stream processing, machine learning, and AI, are crucial for CPS. Decision-making systems and algorithms enhance efficiency. Given their sensitivity, security and privacy in real-time analytics are vital. The study addresses threat detection, privacy preservation, and data security, along*

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*with challenges like data heterogeneity, latency, and scalability. Future prospects include edge AI, fog computing, and blockchain integration.*

## **1.INTRODUCTION**

In the rapidly evolving landscape of modern technology, Cyber-Physical Systems (CPS) represent a groundbreaking paradigm that bridges the gap between the physical and digital worlds. CPS are integrations of computation, networking, and physical processes, where embedded computers and networks monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa. This synergistic interaction enables CPS to perform complex functions, enhancing efficiency, reliability, and automation across a variety of sectors (Yu B. et al.,2020). The concept of CPS has evolved from earlier systems like embedded systems and control systems. The term “Cyber-Physical Systems” was first coined in the early 2000s, driven by advancements in computing, networking, and sensing technologies. The evolution of the Internet of Things (IoT) and advancements in artificial intelligence (AI) have further accelerated the development and deployment of CPS.

Cyber-Physical Systems (CPS) are distinguished from traditional embedded systems by their tight integration and coordination between computational and physical components, enabling real-time processing and response to ensure system stability and performance. CPS involve multiple interconnected subsystems that require seamless interoperability and possess adaptability to changing conditions and requirements in their operational environments (Lesch V.et al.,2023). Cyber-Physical Systems are characterized by their ability to integrate computational algorithms with physical components (Dafflon B.et al.,2021).

Real-time data analytics is pivotal in Cyber-Physical Systems (CPS) as it enables instantaneous decision-making and responsiveness, which are essential for optimizing performance, ensuring safety, and enhancing efficiency across diverse applications. By continuously processing data from sensors and devices, CPS can dynamically adjust operations, predict maintenance needs, and detect security threats, thereby minimizing downtime and reducing operational costs. By using Connected Paper, the Derivative work involved the papers have cited many of the papers in the graph. This typically indicates that they are either surveys of the field or recent relevant works inspired by multiple papers. Selecting a derivative work will highlight all the graph papers it cites, and selecting a graph paper will highlight all the derivative works that cite it. The Base paper considered in the study was “Data-Driven Cyber-Physical Systems via Real-Time Stream Analytics and Machine Learning By Akkaya I. (2016) as shown in Table 1 below.

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