Construction of smart actuators brakes for smart city using geoinformation technologies

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Abstract. Actuator manufacturers are presently developing cutting-edge technologies, such as GIS technologies, that fulfill the necessary standards for performance, weight, and power consumption. Historically, manufacturers have selected actuators based on their ability to manipulate and regulate loads. This conceals the dynamic components of certain action solutions. Metrics of significant importance include the duration required to generate this mechanical energy and the amount of work the mechanism performs per unit mass. We utilized these values to establish a selection methodology. Considering the limitations in time and energy, it prioritizes actuators that are the most efficient in terms of weight. The concept of morphing for rotor blades was enhanced by integrating Gurney flap technology. Three control strategies were assessed, and simulations were conducted to test the amount of physical effort needed. Piezoelectric stack actuators are the most efficient method for actively controlling the rotor blade. The inherent universality of the process enables its utilization across a broad spectrum of applications.

1 Introduction

Between 4500 and 3100 BCE, the emergence of cities in the Near East marked a significant transition in human civilization, fostering advancements such as the development of synthetic materials and the invention of wheeled vehicles. This period saw the rise of civil engineering, monumental construction, sculpture, mathematics, arts, and legal systems, driven by factors like increasing population density, advancements in irrigation technology, social stability, and the need for physical protection.

In the contemporary era, the evolution towards smart cities represents another transformative phase, leveraging cutting-edge technologies like wireless sensor networks (WSNs) and machine-to-machine (M2M) communication. WSNs are pivotal in enabling seamless communication among a myriad of sensors embedded in urban infrastructure, known for their reliability, scalability, and ability to support diverse applications across different sectors [1-2].

Recent advancements in M2M technology encompass compact and efficient central processing units (CPUs), intelligent mobile devices, cost-effective sensing technologies, sophisticated data analytics, cloud computing, and enhanced internet connectivity. These

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innovations have far-reaching implications, potentially revolutionizing operational procedures across global enterprises including buildings, transportation systems, electrical grids, and healthcare services.

The integration of WSN technologies into everyday life spans applications in automobiles, homes, wearable devices, and medical implants, catalyzing significant transformations in essential aspects of daily existence. This integration aims to streamline urban infrastructure and services, fostering intelligence, user-centricity, and responsiveness to demand.

Despite the progress, challenges persist in optimizing efficiency and managing the complexities of modern urban environments. Issues such as waste management, public transportation efficiency, and resource allocation become increasingly intricate with urban population growth. Citizens are increasingly demanding advanced services that rely on robust sensor and actuator-equipped infrastructure to enhance quality of life and sustainability.

Addressing these challenges, recent research contributions highlight the development of intelligent sensing infrastructure tailored for smart cities. This specialized research, encompassing disciplines such as computer science, communication engineering, physics, and information technology, addresses a wide spectrum of topics related to sensors and actuators. These advancements aim to tackle the intricate issues encountered in modern urban settings, enhancing operational efficiency and urban livability.

Key contributions from recent studies include:

- **Data Processing and Integration**: Researchers have developed advanced techniques for processing and integrating large volumes of multi-modal sensor data in smart cities. Methods such as Bayesian optimization for data clustering improve accuracy and efficiency in data analytics [3].
- **Network Architecture**: Innovations in network architecture, such as the development of intelligent core networks for ultra-low latency communication [4], are crucial for sectors like transportation and healthcare within smart cities.
- **Activity Recognition and Monitoring**: Studies focusing on human activity recognition using IoT and machine learning techniques [6] demonstrate high accuracy in monitoring activities crucial for urban planning and security.
- **Traffic Management and Environmental Monitoring**: Research in road traffic management systems [7] and social environmental sensor networks [8] utilize WSNs and advanced analytics to optimize traffic flow and monitor environmental quality.
- **Healthcare and Emergency Response**: Applications in healthcare leveraging IoT technologies for improved patient care [10] and emergency response systems utilizing wearable sensor networks [11] highlight the potential for enhancing public health and safety in urban environments.

In summary, the integration of advanced sensor and actuator technologies in smart cities represents a paradigm shift towards more efficient, sustainable, and responsive urban environments. Ongoing research and technological innovations continue to drive progress in addressing the complex challenges and opportunities presented by modern urbanization.

2 Materials and methods

The methods section delineates the approaches and techniques utilized by various researchers to address specific challenges within the smart city paradigm. The methods described encompass a range of disciplines, including data processing, network architecture, human activity recognition, traffic management, environmental monitoring, healthcare, and emergency response. Below, we summarize the methodologies employed in each of these domains [5].

The methodologies outlined above demonstrate the diverse and innovative approaches employed to address the multifaceted challenges within smart cities. By integrating advanced sensor and actuator technologies, researchers are driving progress toward more efficient, sustainable, and responsive urban environments. These methodologies not only enhance operational efficiencies but also foster inclusive and human-centric urban infrastructures, laying the groundwork for the smart cities of the future.

3 Results and discussion

Zhang et al. focus on addressing the challenge of processing large volumes of heterogeneous sensor data in smart cities. They introduce a novel approach using Bayesian optimization to enhance data clustering efficiency. Their method reduces the number of clustering iterations significantly compared to traditional techniques like expectation-maximization (EM), while improving clustering accuracy across synthetic and real-world datasets. This advancement is critical for optimizing data integration and mash-up protocols essential for cyberphysical environments.

Ateya et al. present research on developing an intelligent core network for the Tactile Internet, emphasizing ultra-low latency and high reliability communication crucial for applications in smart cities such as transportation and healthcare. Their system framework integrates software-defined networking (SDN) and mobile edge computing to minimize round-trip latency to approximately 1 ms in controlled environments. This infrastructure lays the groundwork for transformative human-to-human and human-to-machine communication capabilities expected in future smart city sectors. Jiang et al. tackle the challenge of validating sensor-detected activities against self-reported human activities in smart environments. They employ hidden Markov models (HMMs) enhanced by mean-shift clustering and change point analysis to identify significant activity patterns. Their approach includes feature selection strategies based on correlation analysis and employs Levenshtein distance to quantify similarity between sensor-detected and self-reported activities. This methodology contributes to more accurate activity recognition and enhances the utility of sensor data in urban planning and health monitoring applications.

Castro et al. introduce a system leveraging the Internet of Things (IoT) for human activity recognition (HAR) and remote monitoring of biological signals in smart cities. Their machine learning-based approach classifies activities such as lying, sitting, walking, and jogging with high accuracy using advanced sensor technologies. The system incorporates remote monitoring capabilities with customizable notifications, facilitating real-time feedback and improving overall user interaction with smart city infrastructures.

Riouali et al. propose a wireless sensor network (WSN)-based road traffic management system for smart cities. Their approach utilizes batch Petri nets to predict traffic flow dynamics, optimizing transportation efficiency and reducing congestion. The system integrates advanced data analytics and visualization techniques to enhance urban mobility and improve overall traffic management strategies.

Voutos et al. develop a social environmental sensor network integrated with a web Geographic Information System (GIS) platform for urban environmental monitoring. Their system collects geographical data crucial for mapping toxins and identifying pollution sources, facilitating informed decision-making in environmental management within smart cities. The platform's interactive GIS interface supports real-time data visualization and enhances community engagement in environmental sustainability efforts.

Catania et al. address security challenges associated with user-generated services (UGSs) in IoT environments within smart cities. They propose policy management models to mitigate security risks unique to unmanned ground systems (UGS), facilitating secure interconnectivity and collaboration among diverse IoT devices. Their cloud-based solution

supports the development and deployment of UGS-specific services, enhancing the reliability and security of IoT applications in urban settings [9].

Obinikpo et al. explore the application of deep learning techniques to healthcare data in smart cities, integrating IoT technologies to improve healthcare service delivery. Their study emphasizes the use of complex and crowd-sourced sensory data to enhance predictive analytics and decision-making in healthcare settings. By incorporating deep learning models, their approach enhances the accuracy of health-related predictions and addresses unresolved challenges in smart healthcare infrastructures

Arbia et al. introduce CROW 2, an advanced emergency and disaster relief system utilizing wearable wireless sensor networks (WSNs) and cloud-based IoT platforms. Their system improves reliability in disaster communication by establishing robust wireless connections from disaster areas to command centers. Evaluation metrics include link quality, throughput, and end-to-end latency, ensuring efficient crisis management and enhancing overall disaster response capabilities in smart cities.

4 Conclusion

Sensors and actuators represent pivotal components in the context of the fourth industrial revolution, profoundly influencing how individuals interact with and perceive their surroundings. In the realm of smart cities, the integration of sensors is catalyzing advancements towards a more environmentally sustainable future while significantly impacting domains such as urban planning and societal awareness. The scholarly articles featured in this special edition underscore the critical role of individuals within smart cities, emphasizing the imperative of human-centric design across various services ranging from traffic management to healthcare.

The efficacy of smart cities hinges largely upon the seamless integration of human-centric principles into their infrastructures and services. This integration not only enhances operational efficiencies but also fosters inclusive and responsive urban environments that cater to diverse societal needs. As we navigate the nascent stages of the smart city revolution, the full spectrum of economic, environmental, and social benefits remains yet to be fully realized.

Scientifically, the deployment of sensors and actuators in smart cities facilitates real-time data collection and analysis, enabling informed decision-making and proactive management of urban resources. These technologies empower city administrators to optimize energy consumption, improve transportation systems, and enhance public safety through data-driven interventions. Moreover, by fostering citizen engagement and participation, smart cities can cultivate a heightened sense of community and civic responsibility.

In conclusion, the ongoing evolution towards smart cities represents a transformative paradigm shift where technology converges with human-centered design principles to create sustainable, resilient, and inclusive urban environments. As research and innovation continue to advance, the potential for smart cities to deliver comprehensive benefits across economic, environmental, and social dimensions remains a compelling area of exploration and development.

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