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# Advancing elderly care through big data analytics and machine learning for daily activity characterization

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**ABSTRACT**

Confronted with the ongoing demographic shift characterized by an aging population, society grapples with emerging challenges that extend beyond the provision of targeted health services for the elderly. The focus has broadened to encompass the promotion of well-being and vitality throughout the aging process. Addressing these multifaceted issues demands a comprehensive approach that integrates biomedical components with physical, psychological, and social interventions. In the context of my project, a unique strategy is employed, placing significant emphasis on leveraging big data analytics and machine learning. The primary objective is to systematically observe and characterize the physiological conditions of the elderly, facilitating healthcare professionals in monitoring behaviors and promoting active aging. This undertaking involves meticulous data collection and analysis, employing machine learning algorithms (support vector machine (SVM), gradient boosting) within a framework that harnesses extensive data analytics. Ultimately, this approach enables the identification and characterization of daily routines and physiological states of individuals, contributing to a holistic understanding of aging.



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## 1. INTRODUCTION

In the face of a continuous increase in our society's elderly population, we grapple with a multitude of emerging challenges. At the forefront is the dual goal of providing effective healthcare services tailored to the specific needs of older individuals and actively promoting their overall well-being and engagement in daily life. Achieving these objectives necessitates an optimized healthcare approach that seamlessly integrates biomedical, physical, psychological, and socio-environmental interventions [1], [2]. In this context, capitalizing on the capabilities of big data analytics and machine learning emerges as a compelling alternative to traditional methodologies, with a focus on tapping into the full potential of these technologies [3]. Big data analytics and ML offer a robust framework for the implementation of healthcare services and the analysis of intricate datasets, providing actionable insights to enhance the quality of care for the elderly.

This study presents an innovative data-driven approach, bolstered by the capabilities of big data analytics and ML, to comprehensively assess the daily physiological status of older individuals. Our primary objective is to support healthcare professionals in monitoring behavior and fostering active aging. By gathering and analyzing data through machine learning algorithms [4] within a distributed autonomous agent framework, our aim is to identify and characterize the daily habits and physiological well-being of

these individuals. This article delves into the methodology and implications of our approach, shedding light on its potential to enhance the quality of care for the aging population and promote healthier and more fulfilling lives for the elderly [5]–[7].

Central to our challenge is the creation of a resilient system that seamlessly integrates numerous external and contextual data sources, with a specific focus on providing personalized data analysis for users. In addressing these complex requirements, we advocate for embracing cutting-edge data analytics and ML algorithms, tapping into the vast potential within the domain of big data [8]. The impact of data analytics in healthcare spans various scenarios, encompassing traditional hospital settings as well as individuals navigating partially or fully autonomous lifestyles. A significant evolution in this domain is the widespread adoption of mobile and wearable devices, including smartphones and fitness trackers, which have become inseparable companions intricately connected with users. Beyond merely recording movements and activities, these devices introduce innovative dimensions to our comprehension and analysis of user behavior, particularly within the realm of daily routines and diverse situational contexts [9], [10].

The valuable insights extracted from this analytical framework offer promising potential for future integration with contextual analyses, offering a nuanced guide to support user actions aimed at improving their quality of life [11] and overall well-being. Concurrently, the amassed data serves as a valuable resource for healthcare providers, enabling them to enhance services and optimize costs. The existing literature also showcases a variety of studies delving into diverse approaches to health monitoring systems, addressing areas such as fall detection, mobility and physiology monitoring, and the identification of individuals' daily routines [12]–[14].

Although numerous studies elaborate on methods for recognizing daily activities, it is essential to acknowledge certain limitations. Many of these approaches rely on intrusive laboratory prototypes equipped with sensors directly attached to the body. Additionally, a considerable number of methods are restricted to controlled environments and rely on labeled data, posing challenges when transitioning to real-world applications [15].

A noteworthy emphasis in the examined literature is the introduction of comprehensive architectures for health monitoring systems. This underscores the vital role played by big data analytics and machine learning in tackling crucial aspects such as interoperability issues [16], [17], the seamless integration of diverse data sources and systems, and the provision of personalized and intelligent functionalities within the intricate landscape of healthcare systems. The amalgamation of these findings establishes the foundation for the proposed framework in our study, which not only builds upon but also extends the current understanding of utilizing advanced technologies in healthcare analytics [18]–[20].

In the literature reviewed, it was observed that reliance on a single model is common, which may lead to inaccurate assessments of the physiological state of the elderly. In contrast, our study utilized two models and incorporated two agents, each with distinct roles. This approach was adopted to ensure a more precise understanding of the physiological state of the elderly.

## 2. METHOD

Our research methodology employs a multifaceted approach to enhancing elderly care through the integration of big data analytics and machine learning technologies as seen in the chart Figure 1. Central to our framework is the development of two distinct machine learning agents, each tailored to address key aspects of elderly well-being and activity monitoring. The first agent utilizes support vector machines (SVM) to meticulously characterize and classify the daily behaviors of the elderly. This involves the analysis of comprehensive datasets, including physiological and behavioral data, to identify subtle patterns and variations in daily activities that might indicate changes in health or well-being. The second agent leverages Gradient Boosting, a powerful ensemble learning technique, to predict the intensity level of physical activities undertaken by the elderly. This prediction is vital for assessing the adequacy of physical engagement and its correlation with overall health outcomes. Both agents operate within a robust data processing and storage framework, anchored by MongoDB, which facilitates efficient handling of large-scale time-series data. Our methodology emphasizes a holistic data exploration process, from initial data acquisition and preprocessing to deep analysis utilizing our distributed machine learning agents. Through this comprehensive approach, we aim to significantly enhance the precision of behavioral pattern identification and activity intensity classification, thereby offering insightful contributions to the field of elderly care. This data-driven strategy underscores the potential of technology to improve the quality of life for the elderly by enabling more personalized and proactive care solutions.

To prepare the dataset for characterizing elderly behaviors, we focused on gathering and organizing relevant features essential for prediction. The dataset primarily comprises variables crucial to understanding

the activity levels and lifestyle patterns of the elderly population. Key features such as "calories," "steps," and "minutes sitting" were collected, reflecting various aspects of daily physical activity and sedentary behavior. These features provide insights into the energy expenditure, movement patterns, and sedentary habits of the elderly individuals under study. Additionally, the target variable "Minutes_of_intense_activity" was included, serving as the focal point for prediction. This variable quantifies the duration of intense physical activity, offering valuable information about the seniors' engagement in vigorous exercises or activities. By incorporating these features and the target variable into our dataset, we aimed to facilitate the development of predictive models capable of characterizing elderly behaviors and predicting their levels of intense activity accurately.

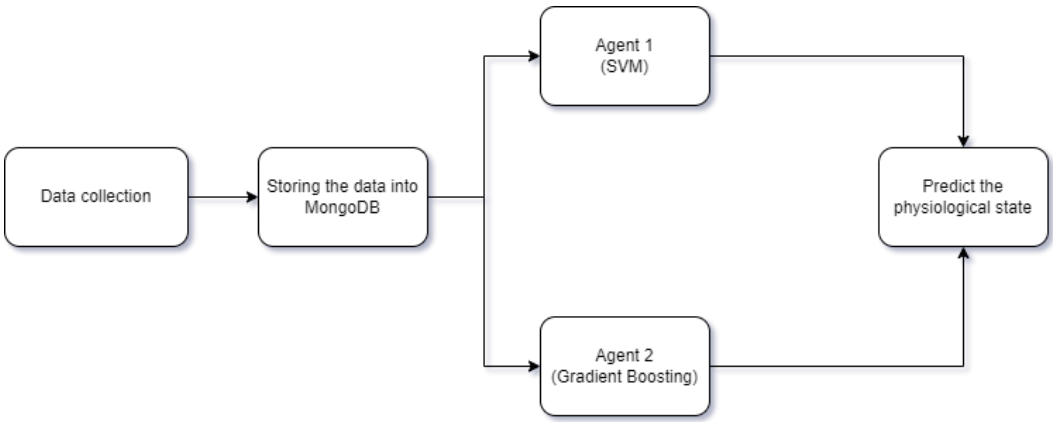


Figure 1. Methodology

Revolutionizing health data analysis necessitates the strategic application of widely adopted, cost-effective principles [21]. This approach, coupled with state-of-the-art data analysis technologies, seeks to establish an intelligent and adaptable infrastructure catering to the diverse requirements of health applications. The core functionality of the platform lies in enhancing personalized monitoring and evaluating individuals' daily habits and overall well-being. Furthermore, it facilitates the seamless integration of external user information while promoting the amalgamation and sharing of knowledge and feedback from users and experts, including healthcare professionals. This holistic system signifies a paradigm shift in health monitoring [22], utilizing advanced data analysis to empower individuals in actively managing their health and fostering collaboration among users and experts in the healthcare domain [23].

Within the context of this study, our primary focus is to underscore the pivotal role of big data analytics and machine learning in advancing elderly care. Emphasizing the significance of data analysis and machine learning techniques, particularly algorithms, is integral to fortifying the cognitive aspects of the proposed project system. In this context, we delve into the profound impact that harnessing extensive datasets can have on enhancing the overall quality of elderly care [24].

Notably, for the processing and storage of data, we chose MongoDB as a robust solution. By leveraging the power of big data analytics, we can unlock valuable insights that contribute to a more nuanced understanding of individual health patterns and needs. Furthermore, the integration of machine learning algorithms serves as a critical catalyst in refining and personalizing the caregiving process, ultimately fostering a more effective and tailored approach to elderly well-being.

Initially, we conducted a comprehensive exploration of the time-series data to gain insights into the behavioral patterns of physiological parameters. This initial analysis played a crucial role in identifying discernible patterns and correlations within the dataset. Subsequently, in a second phase, we employed the classification analysis, utilizing distributed agents to identify and characterize users' physiological and mood states throughout the day. This advanced analysis leveraged machine learning models such as SVM, gradient boosting, providing a more nuanced understanding of regular daily activities. This approach was particularly beneficial as it addressed the inherent limitations of wristbands, which may inaccurately register certain parameters, such as step counts, during routine daily activities. By integrating machine learning techniques, we not only enhanced the accuracy of our information but also uncovered intricate patterns that contribute to a more refined comprehension of users' daily lives.

A thorough analysis of the collected data played a pivotal role in unraveling the intricate behavior of key physiological parameters, including heart rate (bpm), steps, activity level, and sleep level. This analytical effort aimed not only to enhance the accessibility of the gathered data for each user but also to extract valuable insights into their daily routines and the interplay among various physiological aspects.

This analytical journey involved retrieving simulated data from Mango DB, a process meticulously preprocessed to ensure uniformity through steps like normalization. Subsequently, the data underwent a comprehensive examination using a SVM model-an essential step in our analysis. The SVM model serves as a robust tool, allowing us to investigate potential relationships between different variables. By quantifying the influence of specific variables on others, this model provides invaluable insights into trends and associations embedded within our dataset.

When applying the SVM model, our focus extends beyond prediction to the exploration of nuanced relationships between variables. This rigorous approach enhances our ability to extract meaningful information, fostering a deeper understanding of the factors influencing the habits and physiological conditions of our study subjects. Through this methodology, we aim to unravel the underlying intricacies of the data, contributing to a more profound comprehension of the dynamics governing user behavior and physiological responses [25].

The importance of activity classification in the context of the elderly, combined with big data analytics, brings forth several key benefits:

- In-depth understanding of behaviors: this approach yields profound insights into the daily behaviors of the elderly, enriching our understanding of their routines and habits.
- Anomaly detection: by classifying activities, the system contributes to the early identification of abnormal behaviors or unusual patterns, facilitating prompt intervention and medical monitoring [14].
- Personalized care: precise activity classification enables the customization of care plans and interventions tailored to the unique needs of each individual.
- Enhancement of quality of life: a nuanced understanding of daily activities contributes to an enhanced quality of life for the elderly, fostering active and fulfilling aging.
- Safety and well-being: the system plays a crucial role in safeguarding the safety and well-being of the elderly by monitoring their daily activities [26].

In summary, the classification of elderly activities using big data analytics [27] makes a substantial contribution to personalized care, the prevention of health issues, the enhancement of quality of life, and the safety of the elderly. This is accomplished by offering a detailed perspective on their daily activities and behaviors. The noteworthy performance improvement with the inclusion of agents underscores their pivotal role in achieving these objectives [28].

## 3. RESULTS AND DISCUSSION

As a fundamental component of our endeavors to characterize elderly behaviors, we have innovatively developed a system that simulates daily activities for a group of agents representing individuals. The primary goal is to classify their activities, and to accomplish this, we employed a supervised learning model, specifically utilizing a SVM with a radial basis function (RBF) kernel. Our decision was guided by a comprehensive exploration where the SVM exhibited superior performance based on accuracy, Table 1 shows the activities counts versus the model prediction for the same activities in Table 2.

In our research and analysis, we designed an intelligent agent tasked with predicting the intensity level of physical activity-categorized as low, medium, or high. This prediction relies on provided features such as “calories”, “steps”, and “minutes sitting,” alongside the target variable ‘Minutes_of_intense_activity.’ The predictive capabilities of this agent are crucial for discerning the intensity of physical activities based on these input characteristics. To enhance the precision of these predictions, we employed a gradient boosting model, which yielded an impressive accuracy score of 0.88 as shown in Table 3.

Table 1. Activities counts

| Activity | Counts |
|---|---|
| Reading | 1,200 |
| Exercising | 1,400 |
| Sleeping | 900 |
| Watching TV | 700 |
| Eating | 1,100 |

Table 2. Classification SVM result

| Activity | Counts |
|---|---|
| Reading | 1,400 |
| Exercising | 1,300 |
| Sleeping | 1,000 |
| Watching TV | 600 |
| Doi: eating | 1,100 |
| Name: count, | |
| Dtype: int64 | |
| SVM accuracy: 0.7 | |

Table 3. Predictions with gradient boosting

| |
|---|
| Agent predictions (gradient boosting): [‘Faible’, ‘Élevé’, ‘Moyen’, ‘Faible’, ‘Faible’, ‘Faible’, ‘Faible’, ‘Faible’, ‘Élevé’, ‘Élevé’, ----------] |
| Agent score (gradient boosting): 0.8885034906738816 |

The information derived from these predictions serves as a valuable resource for healthcare practitioners, empowering them with a deeper understanding of individual physiological patterns and daily routines. This comprehensive insight equips healthcare professionals to refine the accuracy and personalization of their diagnoses and treatment plans. Ultimately, this leads to an enhancement in the quality of care provided to each patient, as practitioners can tailor interventions based on a nuanced comprehension of individual activity patterns.

The acquired information serves as an invaluable asset for healthcare practitioners, offering profound insights into individual physiological patterns and daily routines. This holistic perspective not only enables them to refine the accuracy and personalization of their diagnoses and treatment plans but also fosters a proactive approach to healthcare. By understanding nuanced activity patterns, practitioners can anticipate potential health issues, enabling preventive measures for enhanced patient well-being. This multifaceted insight, rooted in individual activity behaviors, not only elevates the precision of healthcare interventions but also establishes a foundation for proactive and tailored health management.

## 4. CONCLUSION

In summary, our innovative study pioneers the application of data analytics and machine learning to deepen our understanding of the physiological states of older adults daily. By highlighting the significance of these technologies in enhancing care quality, our findings demonstrate their potential in facilitating active aging, improving care coordination, and personalizing healthcare interventions. Our research offers valuable insights into the physiological patterns of older individuals during various activities and rest periods, underlining the importance of continuous monitoring and analysis to better comprehend their aging process. As we look forward to extending our research to broader demographics and incorporating advanced data analysis tools and real-time monitoring technologies, we are optimistic about the future of healthcare for older adults. Our work represents a significant step forward in realizing a future where older adults lead healthier and more satisfying lives, supported by intelligent, customized healthcare solutions.

Future work will be devoted to improving the clustering analysis by integrating additional parameters, exploring robust strategies for identifying relationships among events within and across daily periods, extending experiments to different population segments, and introducing data analysis for specialized healthcare agents. This ongoing commitment aligns with our dedication to advancing the capabilities of our system for the benefit of diverse user groups and contributing to the evolution of healthcare practices.

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