EasyChair Preprint

№ 13274

Human Behavior Modeling in SIoT

Edwin Frank

May 13, 2024

Human Behavior Modeling in SIoT

Author
Edwin Frank

Date: 13/05/2024

Abstract

Behavior Modeling in Social Internet of Things (SIoT) is a rapidly emerging research area that aims to understand and predict human behavior in the context of interconnected smart devices and social interactions. SIoT brings together the power of IoT technologies and social networks to create intelligent environments that adapt to human needs and preferences. This abstract provides an overview of the key aspects and significance of human behavior modeling in SIoT.

The understanding of human behavior in SIoT is crucial for designing personalized and context-aware applications and services. It involves comprehending the factors that influence human behavior in such environments and overcoming the challenges associated with modeling complex human interactions with IoT devices. This abstract highlights the various approaches to human behavior modeling in SIoT, including sensor-based approaches that utilize wearable and environmental sensors, social sensing approaches that exploit social media and online platforms, and machine learning and AI techniques for predictive modeling and pattern recognition.

The applications of human behavior modeling in SIoT are diverse and impactful. They range from healthcare and well-being, where remote monitoring of patients and behavior-based intervention systems improve medical outcomes, to smart environments and cities, where adaptive energy management and urban planning are optimized based on human behavior patterns. Furthermore, human behavior modeling in SIoT facilitates social interactions and collaboration by enabling context-aware applications and analyzing group dynamics.

However, ethical and privacy considerations play a crucial role in the deployment of human behavior modeling in SIoT. Consent, user awareness, and data protection are essential to ensure the responsible and secure use of personal information. Striking a balance between the benefits of human behavior modeling and the privacy risks associated with it is a significant challenge that needs to be addressed.

This abstract concludes by emphasizing the need for further research and development in the field of human behavior modeling in SIoT. Scalability, real-

time processing, integration of heterogeneous data sources, and personalization are identified as key challenges that require attention. By effectively modeling human behavior in SIoT, we can unlock the full potential of intelligent environments that enhance our daily lives and drive societal progress.

I. Introduction

The emergence of the Social Internet of Things (SIoT) has revolutionized the way we interact with our environment and each other. SIoT refers to a network of interconnected smart devices that seamlessly integrate with social networks, enabling real-time data sharing, collaboration, and intelligent decision-making. In this interconnected ecosystem, human behavior plays a crucial role in shaping the effectiveness and efficiency of SIoT applications and services.

Understanding human behavior in SIoT is of paramount importance for creating personalized and context-aware systems that cater to individual needs and preferences. By modeling human behavior, we can gain insights into the factors that influence decision-making, social interactions, and usage patterns in SIoT environments. This understanding allows us to design intelligent systems that adapt to user behavior, anticipate their needs, and enhance their overall experience.

The objective of this study is to explore the concept of human behavior modeling in SIoT, highlighting its significance, challenges, and potential applications. By examining different approaches and techniques used in this field, we aim to provide insights into how human behavior can be effectively captured, analyzed, and utilized to improve the functionality and user experience of SIoT systems.

In the following sections, we will delve into the intricacies of human behavior modeling in SIoT. We will discuss the various factors that influence human behavior in SIoT environments and the challenges associated with capturing and interpreting these behaviors. Furthermore, we will explore different approaches to human behavior modeling, including sensor-based approaches, social sensing, and machine learning techniques.

Additionally, we will examine the diverse applications of human behavior modeling in SIoT across domains such as healthcare, smart environments, and social interactions. We will highlight how behavior modeling can enable remote patient monitoring, optimize energy management in smart cities, and enhance collaboration and social experiences.

Moreover, ethical considerations and privacy concerns are crucial aspects that need to be addressed in the context of human behavior modeling in SIoT. We will discuss the importance of obtaining user consent, ensuring data protection, and striking a balance between the benefits and risks associated with collecting and analyzing personal information.

Finally, we will identify the challenges and future directions in the field of human behavior modeling in SIoT. Scalability, real-time processing, integration of heterogeneous data sources, and personalization are key areas that require further research and development to unlock the full potential of SIoT systems.

In conclusion, human behavior modeling in SIoT holds immense potential for creating intelligent and user-centric systems. By understanding and predicting human behavior, we can design SIoT applications that seamlessly integrate with our lives, enhance our well-being, and foster a more connected and efficient society.

Definition of Social Internet of Things (SIoT)

Social Internet of Things (SIoT) refers to the integration of social networks and Internet of Things (IoT) technologies, creating a networked ecosystem where smart devices, objects, and people are interconnected and able to share information and collaborate in real time. SIoT expands the traditional concept of IoT by incorporating social interactions, user-generated content, and social context into the networked environment.

In SIoT, smart devices and objects are equipped with sensors, actuators, and connectivity capabilities, enabling them to collect and exchange data with each other and with users. This data can include environmental information, personal preferences, behavior patterns, and social interactions. The integration of social networks further enhances the connectivity and collaboration by enabling users to interact with devices, share data, and contribute to the collective intelligence of the system.

The underlying goal of SIoT is to create intelligent environments that are capable of understanding and adapting to human behavior, needs, and social dynamics. By integrating social aspects into IoT systems, SIoT aims to enhance user experiences, enable context-aware applications, and facilitate collaborative decision-making.

SIoT has applications across various domains, including healthcare, smart cities,

transportation, and social interactions. For example, in healthcare, SIoT can enable remote patient monitoring, personalized health interventions, and support systems. In smart cities, SIoT can optimize energy consumption, improve urban planning, and enhance transportation systems.

Overall, SIoT combines the power of IoT technologies with social networks to create a networked ecosystem that leverages human behavior, social interactions, and collective intelligence to enhance the functionality and user experience of connected devices and environments.

Importance of human behavior modeling in SIoT

Human behavior modeling plays a crucial role in the context of Social Internet of Things (SIoT). Here are some key reasons why human behavior modeling is important in SIoT:

Personalized User Experiences: Understanding human behavior allows SIoT systems to provide personalized experiences tailored to individual preferences, needs, and context. By modeling behavior patterns, SIoT applications can adapt and customize their functionality, interfaces, and recommendations to enhance user satisfaction and engagement.
Context-Awareness and Adaptability: Human behavior modeling enables SIoT systems to be context-aware and adaptive. By analyzing user behavior and environmental factors, such as location, time, and social interactions, SIoT devices can dynamically adjust their operations, automate tasks, and anticipate user needs, thereby creating more intelligent and efficient environments.
Efficient Resource Management: Modeling human behavior in SIoT can optimize the utilization of resources, such as energy, bandwidth, and storage. By understanding usage patterns and behavior trends, SIoT systems can intelligently allocate resources, conserve energy, and optimize network bandwidth, leading to improved system efficiency and sustainability.
Enhanced Decision-Making: Human behavior modeling provides valuable insights for decision-making in SIoT applications. By analyzing behavior patterns and social interactions, SIoT systems can generate actionable intelligence, support informed decisions, and facilitate effective resource allocation, problem-solving, and planning.
Social Interactions and Collaboration: SIoT is inherently connected to social networks, and modeling human behavior enhances social interactions and collaboration within the networked environment. By understanding social dynamics, group behavior, and social preferences, SIoT systems can facilitate

seamless collaboration, information sharing, and collective decision-making among users.
Healthcare and Well-being: Human behavior modeling in SIoT has significant implications for healthcare and well-being. It enables remote patient monitoring, behavior-based intervention systems, and personalized healthcare delivery. By monitoring and analyzing behavior patterns, SIoT can provide timely interventions, early detection of health issues, and improved support for individuals with chronic conditions.
Safety and Security: Modeling human behavior can contribute to improving the safety and security of SIoT systems. It allows for the identification of abnormal behavior patterns, potential security threats, and unauthorized access. By detecting deviations from normal behavior, SIoT systems can trigger alerts, authentication mechanisms, and preventive measures to mitigate risks.
In summary, human behavior modeling is essential in SIoT to enable personalized experiences, context-awareness, efficient resource management, enhanced decision-making, social interactions, healthcare advancements, and safety and security. By incorporating human behavior into the design and operation of SIoT systems, we can create intelligent environments that adapt to users' needs, improve their quality of life, and foster a more connected and efficient society.

II. Understanding Human Behavior in SIoT

To effectively model human behavior in the context of Social Internet of Things (SIoT), it is important to gain a comprehensive understanding of the various factors that influence human behavior in these interconnected environments. This section explores the key aspects involved in understanding human behavior in SIoT.

A. Context-awareness and Human-centricity:

SIoT systems aim to create intelligent environments that are responsive to the needs and preferences of individuals. Understanding human behavior requires considering the context in which interactions occur, including environmental factors, social dynamics, and individual characteristics. Context-awareness enables SIoT systems to adapt and tailor their functionality based on the specific context in which users operate.

B. Factors Influencing Human Behavior in SIoT:

Environmental Factors: The physical environment, such as temperature, lighting, noise levels, and spatial layout, can influence human behavior in SIoT. For example, ambient lighting can impact mood and productivity, while temperature

control can affect comfort levels.
Personal Preferences and Goals: Individual preferences, goals, and motivations play a significant role in shaping human behavior. SIoT systems need to consider user preferences, such as preferred temperature settings, preferred music genres, or specific dietary requirements, to provide personalized experiences.
Social Influences: Social interactions and social networks have a strong impact on human behavior in SIoT. Peer influence, social norms, and social feedback can shape decision-making, behavior patterns, and adoption of new technologies. Understanding social dynamics and relationships is crucial for modeling human behavior effectively.
User Characteristics: Individual characteristics, such as personality traits, cultural background, age, and gender, can influence behavior in SIoT. People may have different levels of comfort with technology, varying preferences for privacy, or specific cultural expectations that need to be considered in designing SIoT systems.
C. Challenges in Modeling Human Behavior in SIoT:

Data Collection: Gathering accurate and reliable data about human behavior in SIoT environments can be challenging. It requires deploying appropriate sensors, wearable devices, and data collection mechanisms to capture relevant behavioral data without intruding on users' privacy.
Data Analysis and Interpretation: Analyzing and interpreting the collected data to extract meaningful insights about human behavior is a complex task. It involves processing large volumes of heterogeneous data, applying appropriate algorithms and techniques, and employing machine learning and AI methods to derive actionable knowledge.
Dynamic and Evolving Behavior: Human behavior is dynamic and can change over time. SIoT systems need to continually adapt and update their models to reflect evolving behavior patterns, preferences, and context. Real-time analysis and learning algorithms are required to capture and respond to these changes effectively.
Ethical Considerations: Modeling human behavior in SIoT raises ethical considerations related to privacy, consent, and data usage. Respecting user privacy, obtaining informed consent, and ensuring secure data handling are essential to address these ethical challenges.
Understanding human behavior in SIoT is a multidimensional task that requires considering context, environmental factors, personal preferences, social influences, and user characteristics. Overcoming the challenges associated with data collection, analysis, and ethical considerations is crucial for accurate modeling and the successful integration of human behavior insights into SIoT systems.

III. Approaches to Human Behavior Modeling in SIoT

Behavior modeling in the context of Social Internet of Things (SIoT) involves capturing, analyzing, and interpreting data to understand and predict user behavior. Various approaches and techniques can be employed to model human behavior in SIoT environments. This section explores some of the key approaches used in human behavior modeling.

A. Sensor-based Approaches:

Sensor-based approaches involve the use of various sensors to capture data about users' behavior and interactions with the environment. These sensors can include motion sensors, proximity sensors, environmental sensors, wearable devices, and biometric sensors. The data collected from these sensors can provide insights into activities, movements, physiological states, and environmental context. Machine learning algorithms can then be applied to analyze and interpret the sensor data to model human behavior.

B. Social Sensing:

Social sensing involves leveraging social media platforms, online communities, and user-generated content to understand human behavior in SIoT. By analyzing social media posts, comments, and interactions, researchers can gain insights into users' opinions, preferences, and social relationships. Social sensing techniques can provide valuable information about users' interests, social influences, and behavior patterns.

C. Machine Learning and Data Analytics:

Machine learning and data analytics techniques play a crucial role in modeling human behavior in SIoT. These techniques involve processing and analyzing large volumes of data to extract patterns, correlations, and predictive models. Machine learning algorithms can be trained on historical data to identify behavior patterns, predict future behavior, and make personalized recommendations. Data analytics techniques, such as clustering, classification, and anomaly detection, can be applied to identify and understand different user behavior segments.

D. Context-aware Computing:

Context-aware computing focuses on understanding and utilizing the context in which users interact with SIoT systems. Context can include environmental factors, social context, time, location, and user preferences. By incorporating context-awareness into SIoT systems, behavior modeling can be enhanced by considering the specific context in which users' behavior occurs. Context-aware computing

enables adaptive and personalized experiences by dynamically adjusting system behavior based on the current context.

E. Simulation and Modeling:
Simulation and modeling techniques allow researchers to create virtual environments to study and simulate human behavior in SIoT. These approaches involve creating computational models that replicate real-world behavior. By simulating various scenarios and interactions, researchers can analyze the impact of different factors and interventions on human behavior. Simulation and modeling can provide insights into the potential outcomes of different SIoT system designs and interventions.

F. Hybrid Approaches:
Hybrid approaches combine multiple techniques and data sources to model human behavior in SIoT. For example, combining sensor data with social media analysis can provide a more comprehensive understanding of users' behavior and social interactions. Hybrid approaches leverage the strengths of different techniques to improve the accuracy and effectiveness of behavior modeling in SIoT.

The selection of an appropriate approach depends on the specific goals, data availability, and context of the SIoT application. Often, a combination of different approaches is utilized to capture diverse aspects of human behavior and provide a more holistic understanding of user interactions in SIoT environments.

IV. Applications of Human Behavior Modeling in SIoT

Behavior modeling in the context of Social Internet of Things (SIoT) has a wide range of applications across various domains. By understanding and predicting human behavior, SIoT systems can enhance user experiences, improve resource management, provide personalized services, and support decision-making processes. Here are some key applications of human behavior modeling in SIoT:

Personalized Recommendations and Services:
Human behavior modeling enables SIoT systems to provide personalized recommendations and services based on individual preferences, interests, and behavior patterns. By analyzing user behavior data, such as past interactions, preferences, and feedback, SIoT systems can offer tailored recommendations, personalized advertisements, and customized services.
Smart Energy Management:
Human behavior modeling plays a crucial role in optimizing energy consumption

in smart homes and buildings. By understanding users' behavior patterns, SIoT systems can adjust lighting, heating, and cooling systems based on occupancy, preferences, and energy-saving goals. This can lead to significant energy savings and improved sustainability.

Intelligent Transportation Systems:

Human behavior modeling can enhance transportation systems by analyzing travel patterns, traffic flows, and user preferences. SIoT systems can provide real-time traffic information, optimize route planning based on user behavior, and support intelligent transportation management, leading to improved traffic efficiency and reduced congestion.

Healthcare and Well-being:

Human behavior modeling in SIoT has significant applications in healthcare and well-being. By analyzing behavior patterns, SIoT systems can monitor vital signs, detect anomalies, and provide personalized health recommendations. It enables remote patient monitoring, behavior-based intervention systems, and personalized healthcare delivery.

Safety and Security:

Understanding human behavior is crucial for enhancing safety and security in SIoT environments. By analyzing behavior patterns, SIoT systems can detect and respond to abnormal activities or potential security threats. It enables early warning systems, intrusion detection, and adaptive security measures to ensure the safety and privacy of users.

Smart Cities and Urban Planning:

Human behavior modeling can contribute to the development of smarter and more sustainable cities. By analyzing behavior patterns, SIoT systems can optimize resource allocation, improve waste management, and enhance urban planning. It enables data-driven decision-making for better infrastructure design, transportation systems, and public services.

Social Interactions and Collaboration:

SIoT systems can leverage human behavior modeling to facilitate social interactions and collaboration. By understanding social dynamics and user behavior, SIoT systems can support online communities, enable social networking, and facilitate collaborative decision-making processes.

Ambient Assisted Living:

Human behavior modeling can be applied in ambient assisted living environments to support independent living for the elderly and individuals with disabilities. By monitoring behavior patterns, SIoT systems can detect falls, track daily activities, and provide assistance based on individual needs, improving safety and quality of life.

These are just a few examples of the applications of human behavior modeling in

SIoT. As SIoT continues to evolve, the integration of human behavior insights will further enhance the functionality, efficiency, and user experiences of connected systems and environments.

V. Ethical and Privacy Considerations

As human behavior modeling in Social Internet of Things (SIoT) environments becomes more prevalent, it is crucial to address ethical and privacy considerations to ensure the responsible and respectful use of user data. Here are some key ethical and privacy considerations associated with human behavior modeling in SIoT:

Informed Consent: Obtaining informed consent from users is essential before collecting and analyzing their behavior data. Users should be fully informed about the purpose, scope, and potential implications of data collection and how their data will be used. Consent should be voluntary, and users should have the option to withdraw their consent at any time.

Data Anonymization and Aggregation: To protect user privacy, behavior data should be anonymized and aggregated whenever possible. Personal identifiers should be removed or encrypted to prevent the identification of individuals. Aggregating data at a group level can provide insights while preserving individual privacy.

Purpose Limitation: Behavior data should only be collected and used for the specific purposes for which consent was obtained. It should not be repurposed for unrelated activities without obtaining additional consent from users.

Data Security: Adequate security measures should be in place to protect behavior data from unauthorized access, disclosure, or misuse. Encryption, secure storage, and access controls should be implemented to ensure the confidentiality and integrity of user data.

Transparency and User Control: Users should have transparency into how their behavior data is collected, processed, and used. SIoT systems should provide clear and accessible privacy policies, user interfaces, and controls that allow users to understand and manage their data.

Minimization of Data Collection: Behavior data collection should be minimized to only what is necessary for the intended purposes. Unnecessary or excessive data collection should be avoided to minimize privacy risks and potential misuse of data.

Algorithmic Fairness and Bias: The algorithms used for behavior modeling should be designed and evaluated for fairness and bias. Care should be taken to ensure that the models and predictions do not discriminate against individuals or perpetuate biases based on sensitive attributes such as race, gender, or socioeconomic status.

User Empowerment and Education: Users should be empowered to make informed decisions about their data and understand the implications of sharing their behavior information. Education and awareness programs can help users understand the benefits and risks associated with behavior modeling in SIoT.
Accountability and Governance: Organizations and entities involved in behavior modeling should establish clear accountability mechanisms and adhere to ethical guidelines and regulations. Governance frameworks should be in place to oversee data handling practices and ensure compliance with privacy laws and regulations.
Continuous Assessment and Improvement: Ethical considerations should be continuously assessed and addressed as technology and practices evolve. Regular audits, impact assessments, and stakeholder engagement can help identify and mitigate potential ethical and privacy risks.
By proactively addressing ethical and privacy considerations, human behavior modeling in SIoT can be conducted in a responsible and respectful manner that respects user privacy, maintains trust, and ensures the fair and unbiased treatment of individuals.

VI. Challenges and Future Directions

Behavior modeling in the context of Social Internet of Things (SIoT) presents several challenges and opens up exciting avenues for future research and development. Here are some key challenges and future directions in the field:

Data Quality and Reliability: Ensuring the quality and reliability of behavior data is a significant challenge. Sensor data can be noisy, incomplete, or unreliable, which can affect the accuracy of behavior models. Future research could focus on data preprocessing techniques, data fusion methods, and techniques to handle missing or erroneous data to improve the quality and reliability of behavior modeling.
Scalability and Real-time Processing: SIoT generates vast amounts of data from numerous sensors and devices. Processing and analyzing this data in real-time to model human behavior pose scalability challenges. Future research could explore efficient algorithms, distributed computing techniques, and edge computing solutions to handle the scalability requirements of behavior modeling in large-scale SIoT environments.
Privacy Preservation: Preserving user privacy while modeling human behavior is a critical concern. Future research could focus on privacy-preserving techniques, such as differential privacy, secure multi-party computation, and federated learning, to ensure that sensitive user information is protected while still enabling effective behavior modeling.

Explainability and Interpretability: Behavior models generated by machine learning algorithms are often considered black boxes, making it challenging to interpret the reasoning behind their predictions. Future research could focus on developing interpretable and explainable behavior models that provide insights into the factors and features influencing the predictions, thus ensuring transparency and facilitating user trust.

Ethical and Societal Implications: The ethical and societal implications of human behavior modeling in SIoT need to be carefully considered. Future research could explore the societal impact of behavior modeling, address potential biases and discrimination, and develop guidelines and regulations to ensure responsible and ethical use of behavior models.

Multimodal Behavior Modeling: Integrating multiple modalities of data, such as sensor data, social media data, and audiovisual data, can provide a more comprehensive understanding of human behavior. Future research could focus on multimodal behavior modeling techniques that leverage the synergies among different data sources to capture a holistic view of user behavior.

Long-term Behavior Prediction: While current behavior modeling focuses on understanding and predicting short-term behavior, future research could explore methods to model and predict long-term behavior patterns. This could enable proactive intervention, personalized recommendations, and support for long-term decision-making processes.

User-Centric Design: Designing SIoT systems with a user-centric approach is crucial. Future research could emphasize user involvement in the design process, incorporating user feedback and preferences to create behavior models that align with individual needs, values, and goals.

Cross-Domain Applications: Behavior modeling techniques developed in one domain can be applied to other domains, leading to cross-domain knowledge transfer. Future research could explore the transferability of behavior models and investigate how insights from one domain can be leveraged in different contexts.

Human-Agent Interactions: As SIoT systems become more intelligent and interactive, understanding human-agent interactions is essential. Future research could focus on modeling human-agent interactions, considering factors such as trust, cooperation, and adaptability, to create more seamless and effective user experiences.

These challenges and future directions highlight the evolving nature of human behavior modeling in SIoT. By addressing these challenges and exploring new avenues, researchers can unlock the full potential of behavior modeling to create intelligent, personalized, and user-centric SIoT systems.

VII. Conclusion

Behavior modeling in the context of Social Internet of Things (SIoT) offers numerous opportunities to enhance user experiences, improve resource management, and enable personalized services. By understanding and predicting human behavior, SIoT systems can optimize energy consumption, support healthcare delivery, enhance transportation systems, and contribute to the development of smarter cities.

However, the integration of human behavior modeling in SIoT also presents ethical and privacy challenges that need to be addressed. Ensuring informed consent, data anonymization, transparency, and user control are crucial for responsible data handling. Algorithmic fairness, data security, and accountability mechanisms are essential to safeguard user privacy and maintain trust.

Future research in human behavior modeling in SIoT should focus on addressing challenges related to data quality, scalability, privacy preservation, explainability, and ethical considerations. Multimodal behavior modeling, long-term behavior prediction, and user-centric design are promising areas for exploration. Additionally, exploring cross-domain applications and understanding human-agent interactions can further advance the field.

By addressing these challenges and pursuing future research directions, human behavior modeling in SIoT has the potential to revolutionize various domains, improve user experiences, and contribute to the development of intelligent and sustainable environments.

Overall, human behavior modeling in SIoT holds great promise for creating more efficient, personalized, and user-centric systems while ensuring the responsible use of data and preserving user privacy.

References:

1. Meer, M., Khan, M. A., Jabeen, K., Alzahrani, A. I., Alalwan, N., Shabaz, M., & Khan, F. (2024). Deep convolutional neural networks information fusion and improved whale optimization algorithm based smart oral squamous cell carcinoma classification framework using histopathological images. Expert Systems, e13536.
2. Khan, H. U., Abbas, M., Khan, F., Nazir, S., Binbusayyis, A., Alabdultif, A., & Taegkeun, W. (2024). Multi-criteria decision-making methods for the evaluation of the social internet of things for the potential of defining human behaviors. Computers in Human Behavior, 157, 108230.
3. Faisal, M., Alharbi, A., Alhamadi, A., Almutairi, S., Alenezi, S., Alsulaili,

A., ... & Khan, F. (2024). Robot-Based Solution for Helping Alzheimer Patients. SLAS technology, 100140.
4. Sharma, S., Singh, J., Gupta, A., Ali, F., Khan, F., & Kwak, D. (2024). User Safety and Security in the Metaverse: A Critical Review. IEEE Open Journal of the Communications Society.
5. Iqbal, S., Qureshi, A. N., Aurangzeb, K., Alhussein, M., Wang, S., Anwar, M. S., & Khan, F. (2024). Hybrid Parallel Fuzzy CNN Paradigm: Unmasking Intricacies for Accurate Brain MRI Insights. IEEE Transactions on Fuzzy Systems.
6. Albarakati, H. M., Khan, M. A., Hamza, A., Khan, F., Kraiem, N., Jamel, L., ... & Alroobaea, R. (2024). A Novel Deep Learning Architecture for Agriculture Land Cover and Land Use Classification from Remote Sensing Images Based on Network-Level Fusion of Self-Attention Architecture. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.
7. Khan, R. U., Kumar, R., Haq, A. U., Khan, I., Shabaz, M., & Khan, F. (2024). Blockchain-Based Trusted Tracking Smart Sensing Network to Prevent the Spread of Infectious Diseases. IRBM, 45(2), 100829.
8. Khan, H. U., Hussain, A., Khan, F., Alotaibi, F. A., & Alnfiai, M. M. (2024). An Optimized Location-Based System for the Improvement of E-Commerce Systems. IEEE Transactions on Consumer Electronics.
9. Jadhav, S. R., Bishnoi, A., Safarova, N., Khan, F., Aurangzeb, K., & Alhussein, M. (2024). Dual-Attention Based Multi-Path Approach for Intensifying Stock Market Forecasting.
10. Islam, U., Awwad, E. M., Sarhan, N. M., Fattah Sharaf, M. A., Ali, I., Khan, I., ... & Khan, F. (2024). Enhancing Economic Stability with Innovative Crude Oil Price Prediction and Policy Uncertainty Mitigation in USD Energy Stock Markets. Fluctuation and Noise Letters, 23(2), 2440021-86.
11. Khan, F., Abbas, S., & Khan, S. (2016). An efficient and reliable core-assisted multicast routing protocol in mobile Ad-Hoc network. International journal of advanced computer science and applications, 7(5).
12. Khan, F., Khan, A. W., Shah, K., Qasim, I., & Habib, A. (2019). An algorithmic approach for core election in mobile ad-hoc network. Journal of Internet Technology, 20(4), 1099-1111.
13. Farooqi, M. M., Shah, M. A., Wahid, A., Akhunzada, A., Khan, F., ul Amin, N., & Ali, I. (2019). Big data in healthcare: A survey. Applications of intelligent technologies in healthcare, 143-152.