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Smart Home Automation with Smart Metering using ZigBee Technology and Deep Belief Network

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***Abstract*—The smart metering in the smart home application is vital one to ensure the reduction of energy usage and become a hot topic in the research field with the increasing usage of energy in both industrial and residential. With the advance technologies the energy saving techniques are used for the smart homes. The Internet of Things (IoT) devices are used for monitoring, controlling, and detecting the devices for the smart home applications. In this study, a novel Deep Belief Neural Network (DBN) approach for analyzing the data that are gathered from smart home applications with IoT devices, and big data technologies which promises the smart metering in smart home applications is proposed. The energy consumption patterns and classifications are effectuated with the proposed DBN approach and ensures the safety of the home. Experimental study was made and analyzed the performance of the proposed work in terms energy consumption of different devices of smart home applications. Our proposed approach surpasses all the other approaches for the smart metering based smart applications.**

Keywords—Smart Home, Smart Metering, Zigbee Protocol, Deep Belief Neural Network, Energy.

I. INTRODUCTION

Smart houses [1] were designed to be automated and convenient; however, in the past decade, residential systems have been improved with more sophisticated characteristics to provide advantages in a wide range of other industries. The ambient-assisted living (AAL) [2] environment is particularly significant for these, the innovations seek to improve living circumstances for senior citizens by fostering independence and self-assurance. To identify potentially unsafe conditions for the residents or, more broadly, to determine trends and make estimations, expertise centers on detecting the surroundings and recording user behaviors. In addition to automating some tasks and relieving users of responsibility, the device may also utilize behavioral assessment (BA) [3] to spot patterns that indicate a need for special concentration and increase people's perceptions of security. The precise location of the client can improve these amenities, for safety and protection reasons, it is essential to identify whether an individual is close to a risky place or to understand the location of a harmful occurrence like a tumble. In this situation, an approximate calculation of where the individual is situated is frequently adequate, In addition, it is important to keep in mind that reliable adaptation can be consequently accomplished by determining the way the person interacts with the security technique [4] implemented equipment in the home, each of which has a referred-to and secured location. In this context, specific measures must be put into place to pinpoint the real individual who engaged with a particular detector, notably for BA reasons in a situation filled by several clients. It has broadband connections that allow users to automatically manage daily chores to save both time and funds while ensuring safety and protection, the idea of being able to control the climate inside, lighting levels, and secure gates from any handheld device. It may have a detrimental effect on psychological functions including innovation, retention, and concentration. For the issues like security, energy saving and comfort of the smart home application a novel approach that uses Zigbee protocol based Deep Belief Neural Network (DBN) for the analysis of data that are collected from the smart home applications is used.

The roadmap of the article is, the relevant works are analyzed in the section 2, the proposed methodology is elucidated in section 3. The experimental analysis is investigated in section 4. Finally the work is concluded in section 5.

II. LITERATURE SURVEY

Bianchi et al. [5] have presented a received signal strength indicator (RSSI) a method for room-level positioning using fingerprint. It is an authentication technique based on receiver behavior assessment. Additionally, the location of the genuine user is inferred from the way that one communicates with the network of home gadgets installed in the building. If multiple individuals reside in the residence, it is crucial to determine whether to utilize a specific gadget. Thus, aggregating strategies are used to raise precision to a suitable degree while having little to no influence on energy usage and the

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longevity of batteries. Hence, these methods are not entirely suited for widespread purposes.

Chen et al. [6] have described the active loading state identification method used a successful technique to determine the capacity of gadgets in various operating states. The two main phases of the suggested technique for identifying device activity states are the application of energy analysis of features initially and then the use of an experienced predictor employing a support vector machine to distinguish between different system states. Residential power administration must be used to successfully control the standby electricity use of the increasing number of domestic power gadgets. Hence, the most appropriate period duration to cut off backup electricity for different devices is still a major issue.

Ke et al. [7] have developed a fast join process (FJP) and improved it to speed up the development of the Zigbee system. Meters unexpectedly lose the relationships in any LAN, and the cluster must continue to operate regardless of numerous foreseen and unexpected circumstances. After such disturbances, systems built according to traditional designs reassemble one another, for speeding up the build-up of networks and affiliation outcomes, and the device may both increase dependability. Thus, the method takes too much time.

Mokhtari et al. [8] suggested Representational State Transfer (REST) constructed infrastructure has seven distinct stages, including a tangible, computer in the fog, a system, web-based assistance, a recess, and software to accommodate intelligent homes' appropriate handling of information and interaction needs. Sensors and intelligent hardware that control the residential surroundings and its occupants are part of the tangible component of a smart residence. Then, utilizing the connected home network level, any required information will be delivered to the cloud server surface. The flexible alternative for handling and conserving data is provided by the distributed computation platform. Therefore, the processing and retrieval capabilities are limited.

Li et al. [9] highlighted the Smart Energy Theft System (SETS) which gathers information gathered by surveillance equipment and examines it for detecting vandalism of energy. Because any intrusions for loss of energy, irrespective of altering equipment or modifying information, may be determined, it is advisable to deploy an autonomous electronics device right at the smart meters. It is more reliable than simply checking the information retrieved from the operator's or a cloud-based database since numerous additional variables might influence the investigation. Nevertheless, it is difficult to deploy the surveillance systems.

III. MATERIALS AND METHODS

To develop new useful applications, many opportunities are provided with social and personal domain IoT application is home automation (HA). For home automation, the set of techniques referred that is the combination of welfare, management of energy and security. The systems of HA needs an essential is comfort. While applying HA in IoT that leads to device interconnectivity which ensured some communication systems. The unified protocols deficiency cause these problems and also smart cities coexisting several various users' lifestyles. While implementing the proposed framework, it included functionality of proposed work and its architecture that is present in the following sub-sections. The smart home security and comfort is contributed with proposed HA management model and also it save energy in residents. The IoT devices are used to collect data. The energy consumption as well as big data technologies are managed by using deep learning called deep belief network (DBN). The DBN model process and analyze all the information thereby learning the pattern of energy consumption. For energy waste, the relevant recommendations are made with user behavior patterns. For better scalability, the system maintenance is facilitated with different layers of proposed model such as device, data, communication, management, security, IoT services and presentations layers respectively.

A. Device layer

In order to provide better control to domestic devices, an effective energy-saving system consider resident preferences. The resident age, temperature changes due to seasons, natural ventilation and external environment are the factors based on home energy consumption. Consider few devices such as controllers, actuators, sensors and gateways are for the layer of device with respect to proposed model.

B. Communication layer

The reliable communication networks is the requirement of proposed model and the user behavior data with energy consumption data are positively retrieved. The proposed communication layer uses the protocol concept of ZigBee [10]. The minimum power wireless network standard and IEEE802.15.4 ZigBee protocol develops ZigBee Alliance. The personal networks are established using high-level protocol and it is less cost with digital radios cantinas low-power which pass wirelessly data to enlarger fields. Additionally, the long battery life with secure networking is the requirement of ZigBee that has an applications of low information rate. The mesh, star and tree topologies are various types of topologies considered in ZigBee. Both efficient and intelligent based smart home devices controlled by home residents supported with the layer of communication [11]. In smart home, install various IoT devices that provides information. Few of home information namely the temperature of air conditioners, room temperatures, energy consumption, water consumption and etc. are the information provided due to these IoT data. The communication layer based proposed structure is outlined in Figure 1. In the monitoring of smart home, the key element is sensors. How much consumption of power is identified and analyzed by gathering the senor real time data. Daily monitor and analyze these information by users they need to process the adjustment of energy saving.

C. Management Layer

The information collected by the protocols are analyzed and controlled by using the Deep Belief Neural Network in this layer. the commands that are used for the accessing of data are concealed in this layer and thus security of the system has been enhanced. The patterns of users and classification of the houses based on the consumed energy patterns are performed using the DBN and is explained below,

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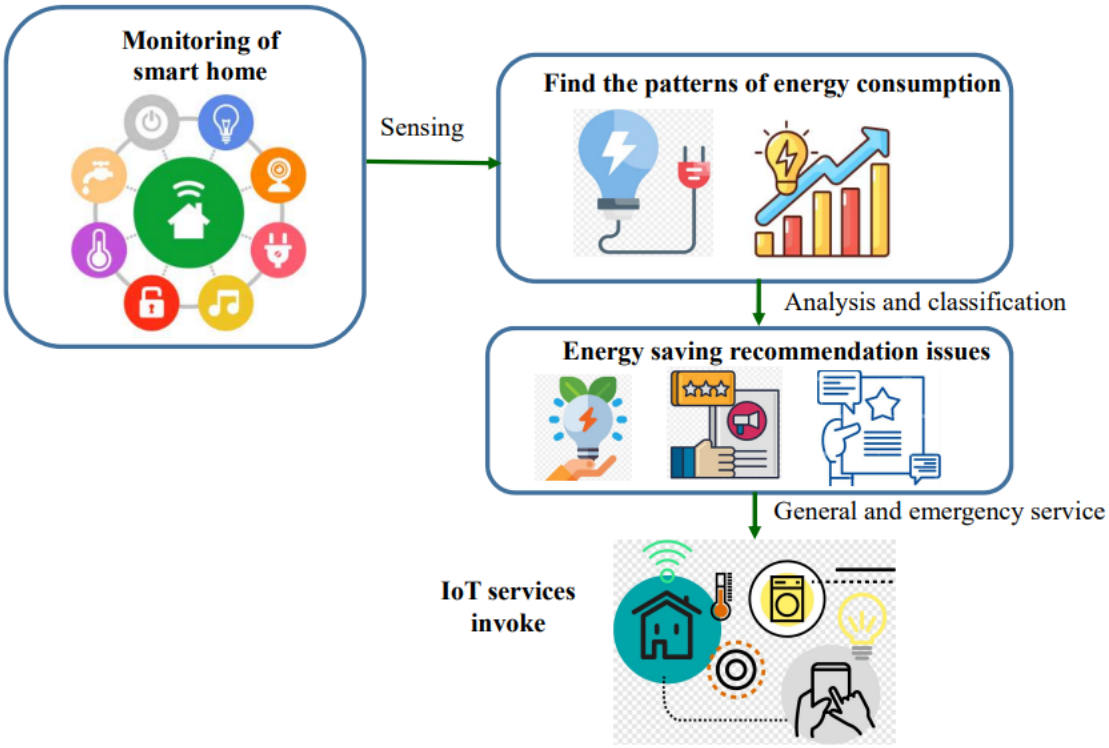

Fig. 1. Proposed model structure based on the layer of communication

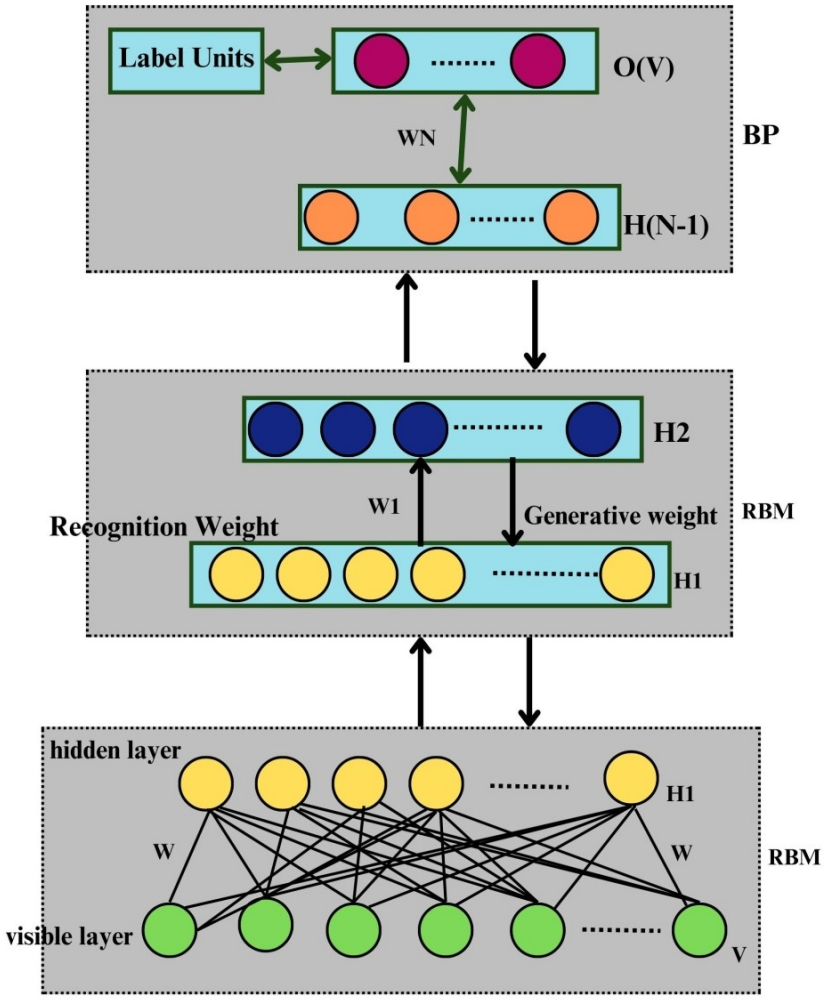

Fig. 2. Proposed DBN for the analyzing the information collected

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The DBN is merged with RBM (multiple unsupervised learning networks) [12] and BP (supervised learning network). The DBN architecture is illustrated in figure 2 with two layers of undirected symmetric connections and directed connections of output layers. upward arrow in the figure shows the detection model and generative model is shown as downward arrows. The mathematical illustration of DBN with N layers are enabled as the joint distribution of V and H layers for K=1:N as is expressed as,

$$P(V,H_1,....H_N) = P(V|H_1)\prod_{K=1:N-2} P(H_K|H_{K-1})P(H_{N-1}|H_N) \quad (1)$$

Training of DBN includes two stages such as training the RBM layers with the contrastive divergence (CD) algorithm and using BP for the fine tuning the parameters. The first stage to train the unsupervised layer using layer by layer approach and greedy algorithm is utilized. The first part of the distribution $P(H_1|V)$ is sampled and using the posterior distribution $P(V|H_1)$ the visible variables are sampled [13]. Similarly the sampling the hidden layers are effectuated in the same procedure. This is repeated until it reaches the equilibrium distribution is obtained. Henceforth the input vector V for the optimal determination of the input learning of the RBM second layer and repeat it for H2 and continues. The parameters of DBN are fine-tuned using BP learning based gradient descent algorithm. It effectuated the supervised cost function among the predicted and expected output vector. The proposed DBN is used in the management layer for the removing the unwanted data and editing the user profiles and analyses the information of smart metering for saving the energy.

D. IoT based Services Layer

This is the main layer for the communication between the application and management layer. moreover, the users can effortlessly communicate with the functionalities of the system and the main components of the layer are listed as below,

The information are collected with the REST API using the Zigbee protocol with higher capacity.

This layer is used to select the service provider by validating and passing the parameters to the presentation layer. this can deny or access the services based on the authentication information and parameters.

E. Security Layer

The data confidentiality between the device layer and end users are ensured with this layer. For the communication or channel between the security and device layer, the communication layer and the administration layers are utilized. The components used in this layer are authentication and authorization. The validation of the something or someone is performed by this component and authorization is used for the authentication of the system.

F. Presentation layer

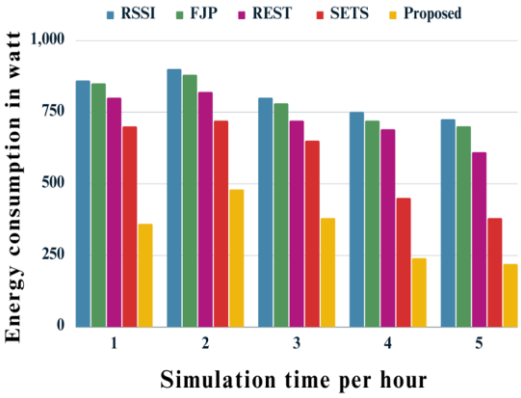
The main menu options of this layer are home, statistics, favorites, rooms and electronic devices. this also helps to add or delete the menus according to the users requirements. It can also ensure viewing the existing clients and alter the application settings. Thus our proposed system guarantees the comfortness, safety, and energy saving of the smart homes using the Zigbee protocols.

IV. Experimental Analysis and Discussion

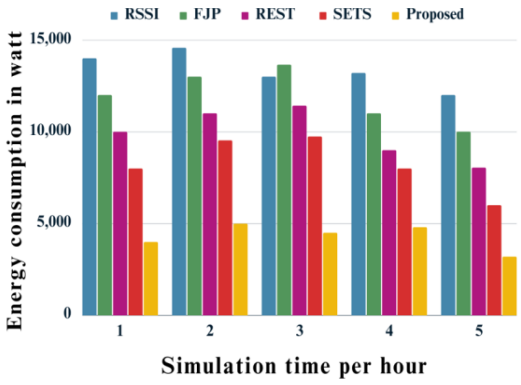
This part discuss the proposed model effectiveness by achieving the results debate and comprehensive exploration. The experimental investigation handled in python platform. Particularly, the premeditated simulated setting reveals the proposed DBN with zigbee and smart metering in HA efficiency. The big data technologies and DBN service layer collects the data and in smart homes, an important expectation of energy consumption is resolved.

A. Performance Evaluation

In energy consumption, the monthly, weekly and daily basis data analysis is conducted. Figure 3 conduct the experimental investigation of energy consumption results for various electronic things. Figure 3(a) to 3 (b) shows the electronic things such as refrigerator, fan, air conditioner and television results of energy consumption. The methods such as RSSI [5], FJP [7], REST [8], SETS [9] and proposed to validate the energy consumption results for the electronic thing of refrigerator, fan, air conditioner and television. Based on smart appliances, the proposed model with respect to decreases the energy consumption. Due to the home automation, the proposed method took minimum of energy consumption in each hour of simulation time while contrasted with other RSSI, FJP, REST and SETS methods with respect to electronic things such as refrigerator, fan, air conditioner and television.



(a)



(b)

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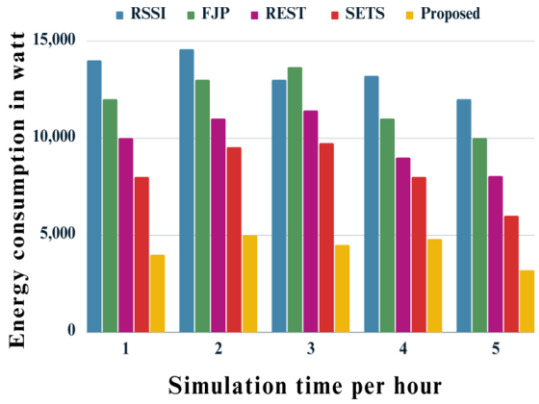

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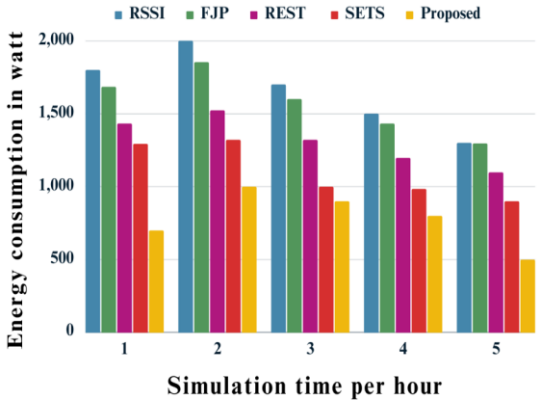

(d)

Fig. 3. State-of-art of energy consumption results for various electronic things, (a) Refrigerator, (b) Fan, (c) Air Conditioner and (d) Television

V. CONCLUSION

In the residential sector, increase of energy consumption is the key research area. Enlarger number of data is analyzed and obtained via the technologies of big data analytics with DBN. The home comfort is ensured with user behavior patterns identification, energy consumption efficiency classification and system analyzes utilizes based on DBN and ZigBee models. The experimental investigation handled in python platform and it provided the reduction of energy consumption based on various electronic equipment such as refrigerator, fan, air conditioner and television. By this, the proposed method offers minimum consumption of energy when comparing with previous RSSI, FJP, REST and SETS methods. This model provided the smart home automation based energy saved model.

REFERENCES

[1] B. D. Davis, J. C. Mason and M. Anwar, "Vulnerability Studies and Security Postures of IoT Devices: A Smart Home Case Study," in *IEEE Internet of Things Journal*, vol. 7, no. 10, pp. 10102-10110, Oct. 2020, doi: 10.1109/JIOT.2020.2983983.

[2] C. Sandeepa, C. Moremada, N. Dissanayaka, T. Gamage and M. Liyanage, "An Emergency Situation Detection System for Ambient Assisted Living," *2020 IEEE International Conference on Communications Workshops (ICC Workshops)*, Dublin, Ireland, 2020, pp. 1-6, doi: 10.1109/ICCWorkshops49005.2020.9145053.

[3] M. Foster *et al.*, "Preliminary Evaluation of a Wearable Sensor System for Heart Rate Assessment in Guide Dog Puppies," in *IEEE Sensors Journal*, vol. 20, no. 16, pp. 9449-9459, 15 Aug.15, 2020, doi: 10.1109/JSEN.2020.2986159.

[4] P. Anand, Y. Singh, A. Selwal, M. Alazab, S. Tanwar and N. Kumar, "IoT Vulnerability Assessment for Sustainable Computing: Threats, Current Solutions, and Open Challenges," in *IEEE Access*, vol. 8, pp. 168825-168853, 2020, doi: 10.1109/ACCESS.2020.3022842.

[5] V. Bianchi, P. Ciampolini and I. De Munari, "RSSI-Based Indoor Localization and Identification for ZigBee Wireless Sensor Networks in Smart Homes," in *IEEE Transactions on Instrumentation and Measurement*, vol. 68, no. 2, pp. 566-575, Feb. 2019, doi: 10.1109/TIM.2018.2851675.

[6] M. -T. Chen and C. -M. Lin, "Standby Power Management of a Smart Home Appliance by Using Energy Saving System With Active Loading Feature Identification," in *IEEE Transactions on Consumer Electronics*, vol. 65, no. 1, pp. 11-17, Feb. 2019, doi: 10.1109/TCE.2018.2885034.

[7] C. -H. Ke, S. -Y. Hsieh, T. -C. Lin and T. -H. Ho, "Efficiency Network Construction of Advanced Metering Infrastructure Using Zigbee," in *IEEE Transactions on Mobile Computing*, vol. 18, no. 4, pp. 801-813, 1 April 2019, doi: 10.1109/TMC.2018.2848237.

[8] G. Mokhtari, A. Anvari-Moghaddam and Q. Zhang, "A New Layered Architecture for Future Big Data-Driven Smart Homes," in *IEEE Access*, vol. 7, pp. 19002-19012, 2019, doi: 10.1109/ACCESS.2019.2896403.

[9] W. Li, T. Logenthiran, V. -T. Phan and W. L. Woo, "A Novel Smart Energy Theft System (SETS) for IoT-Based Smart Home," in *IEEE Internet of Things Journal*, vol. 6, no. 3, pp. 5531-5539, June 2019, doi: 10.1109/JIOT.2019.2903281.

[10] C. C. Chan, "The State of the Art of Electric, Hybrid, and Fuel Cell Vehicles," in *Proceedings of the IEEE*, vol. 95, no. 4, pp. 704-718, April 2007, doi: 10.1109/JPROC.2007.892489.

[11] C. -A. Bilaţiu, S. I. Cosman, R. -A. Marţiş, C. S. Marţiş and S. Morariu, "Identification and Evaluation of Electric and Hybrid Vehicles Propulsion Systems," *2019 Electric Vehicles International Conference (EV)*, Bucharest, Romania, 2019, pp. 1-5, doi: 10.1109/EV.2019.8892965.

[12] N. Gao, L. Gao, Q. Gao and H. Wang, "An Intrusion Detection Model Based on Deep Belief Networks," *2014 Second International Conference on Advanced Cloud and Big Data*, Huangshan, China, 2014, pp. 247-252, doi: 10.1109/CBD.2014.41.

[13] Da-Zeng Tian and Ming-Hu Ha, "Applications of wavelet transform in medical image processing," *Proceedings of 2004 International Conference on Machine Learning and Cybernetics (IEEE Cat. No.04EX826)*, Shanghai, China, 2004, pp. 1816-1821 vol.3, doi: 10.1109/ICMLC.2004.1382071.

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