Current and Potential Applications of IoT in Multimedia Communication System

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Abstract

Developing wireless technology and the exploitation of automated systems has demanded an innovative method of handling the objects that share multimedia information. The monitoring and automation system has progressed towards the Multimedia Internet of Things (M-IoT) whereas circumstance is entirely transformed to meet the requirements of the fast-moving world. Internet of Things (IoT) engrosses abundant objects and makes those objects think intelligently, which decides on their own by perceiving the situation of the circumstance. The incorporation of IoT into the real-time application facilitates the information exchange and utilizes the information for monitoring as well as prevention of complicated situations. The M-IoT-based conceptual framework and integration of smart objects in real-time applications have enriched the standard of living. M-IoT is widely used in health care, industry, and monitoring event. In this article, the specialized architecture of M-IoT is discussed along with diverse applications. Additionally, the metrics that assess the standard of M-IoT are summarized.

1. Introduction

In the current era of wireless networking, unified connectivity and pervasive computing is not an excessive challenge. Human and machine communication was constrained at the preliminary stage of internet progression and the development in internet technology has made communication amongst everything as in IoT. It is the newest technology that generates a widespread network of devices and machines implanted with software that is capable of exchanging and communicating information with each other over the internet [1]. The substantial aspect of IoT is that it can renovate an object into an intelligent smart object by offering to communicate, actuating, computing, and sensing ability to the object [2].

IoT generates data from the connected object and it is used for further analysis and decision making. The exponential escalation in internet connectivity and gadgets has necessitated the IoT that bridges the gap among the objects and services [3]. In IoT, an object determines everything that can communicate or not, and the flow of an event, as well as data created by the interconnection of smart things, facilitate the process of management, control, decision making, tracking, and coordination. Bind of heterogeneous techniques and significance has made IoT a great success [4, 5]. Figure 1 shows the significance of IoT.

Multimedia Internet of Things (M-IoT) gadgets are diverse from the devices formulated from the IoT technology [6]. It also necessitates huge memory, power of computation and they are high-power utilizers with huge bandwidth. The IoT exploitation in real-time is diverse from smart cities, smart grids, smart hospitals, industrial IoT, smart homes, and smart agriculture. The chief characters of M-IoT are reliable and timely in delivering the needed data. M-IoT enforces quality of service (QoS) necessities and demands effective architecture for the transmission network [7].

The perception of QoS from the user is quality of experience (QoE) and it is subsequently characterized as subjective or objective. The multifold generation of multimedia information is surging [8, 9]. This context also generates numerous challenges to store, process, share, and exchange information. Data

processing necessitates cloud, edge, and fog computing technology. Routing protocol for low-power and lossy networks (RPL) is considered the standardized IoT routing protocol. It necessitates subsequent progression by encompassing the balancing of load, fault tolerance, delay, and energy-aware M-IoT deployment circumstances [10].

The characteristics of IoT maintain the communication with multimedia, which is sensitive to delay and hungry of bandwidth. The quick generation of traffic due to multimedia data in IoT has made a possible way for creating new innovative approaches to meet the necessities. M-IoT devices necessitate greater memory, quick computation, and huge bandwidth of resources to progress the data. Generally, communication encompasses multipoint-to-multipoint and multipoint-to-point contexts. Real-world multimedia applications comprise response systems for emergencies, monitoring the traffic, Industrial IoT (IIoT), an inspection of crime, smart agriculture, smart homes, smart cities, smart hospitals, and surveillance systems [11].

The remainder of the article is organized as follows: the specialized architecture of M-IoT for every individual application is discussed in Sect. 2, diverse applications of M-IoT is summarized in Sect. 3, the metrics that assess the standard of M-IoT are detailed in Sect. 4 and the article is concluded in Sect. 5.

2. M-iot Architecture

The nature of IoT supports multimedia-based applications and the possibility of multimedia in the real-time application is achieved by IoT. Though, it poses diverse challenges where multimedia applications are delay-sensitive and bandwidth-hungry. IoT devices lack computational and radio resources. The emergence of huge multimedia data in IoT may lead to vast vague data. To handle this issue, different forms of Multimedia-IoT architecture are formulated for analyzing, processing, and utilizes the generated data reliably. Different architectures developed for different application and scenario is summarised in Table 1 whereas the M-IoT architecture is illustrated in Fig. 2.

Table 1
Architectures of M-IoT

Architecture for Specialised Area	Year	Proposed Layer	Inference
M-IoT Architecture for Big Data Layer [12]	2018	Application Layer	Necessary services are delivered by standardized protocols.
		Multimodal Computational Layer	The functionality of the hardware services is delivered.
		Middleware Layer	Software range of assistance is offered where management, recovery, and services of data are accomplished.
		Communication Layer	It poses a similar network, link for functionality, and transportation links.
		Physical Layer	The information aggregated from the multimedia or scalar is attained based on modality.
		Identification Layer	The object ID is utilized for the detection of devices.
Secured Architecture for Multimedia Traffic [13–16]	2011	Watermarking	Restricts illegal distribution and the origin is identified.
		Authentication	Delivers access control and management facility.
		Rekeying of Batch	Accommodates numerous multimedia data.
		Management of Key	Flow, service, scalability, and user control are attained.
M-IoT Architecture for Agent-based System [17]	2018	Communications and Multimedia supported devices	The data stream is supported with multimedia data accomplished at the communication layer.
		M-IoT resources and services	Diverse services based on the resources are processed in this layer.
		Connectors of resources	The resource generators are correlated or connected by the connectors.
		Agents for the execution of service	Service and resource sharing are accomplished by the agent layer.
		Applications	Interface with effective interaction is provided.

Architecture for Specialised Area	Year	Proposed Layer	Inference
M-IoT Architecture for Multi-agent based System [18]	2015	System based on Multi-Agent	The cloud accomplishes sharing of content, diverse composition of service, analysis, and mining of data.
		Cloud system for multimedia	Multimedia-supported middleware, device identification, agent naming, storage, and process of data are attained by the cloud.
		Addressability and reporting	It encompasses the capabilities of addressability and reporting that enable technology features in the link layers.
		Sensing the multimedia data	The process of pre-transmission is accomplished.
Hybridized Fog with Cloud architecture for M-IoT [19]	2018	Mobile client	The consumer service is offered and reliable service is accomplished.
		Fog node	Holds fog nodes in IoT and other smart-gadgets
		Cloud at a remote location	Crowdsourcing, service across the social network, stationary or mobile services are accomplished.
AI-supported SDN for management of traffic based architecture [20]	2018	SDN for Cloud-based on AI	SDN governs the overall performance and services of the SDN.
		Network Heads	Responsible for data gathering.
		Network for IoT	The data transmission and gathering process is accomplished by the IoT network.

3. Applications Of M-iot

The multimedia information is engrossed with the internet and interaction over the objects without the intervention of humans that improves the standard of living. The information in the multimedia data is high and rich in quality. Features like detection of motion, identification of license plate, recognition of the face, an indication of drowsiness for drivers, status of the patient, authorization via scanning of the retina, identification of crime, crowd, path hole, and obstacle identification. These approaches are attained by the extraction, analytics, and aggregation of data. A heterogeneous scheme of multimedia information, content analytics via the cloud, and data transmission ubiquitously. Diverse forms of M-IoTbased application are classified and discussed in this section that is given in Table 2.

3.1. E-Health Care System

Multimedia information offers a communication medium for cooperation and observation with diverse aspects of daily life at various stages of granularity across numerous applications. The health status of

every individual is observed and monitored by health media whereas the personal health of an individual is monitored. Incorporation of health media with personal data across the network estimated every aspect of an individual by utilizing the future health features in IoT. The multimedia information is acquired with the assistance of sensors and electronic objects, which are stored and processed via the cloud for retrieving needful information.

The elderly people are monitored from their localization by the experts through real-time monitoring of video surveillance systems. The infants and their health are monitored by the tutors or parents through an efficient monitoring system. The health media is stored in the cloud that is processed for the diagnosis of disease. Intensive care and patient monitoring system are efficiently implemented by the M-IoT. The telemedicine system is initiated with the advent of IoT and wireless communication systems.

Telemedicine is defined as a virtual health care system and necessary medical services are offered to the patients, which exchange health media among the distant patient and health experts. This service is accomplished by an effective telecommunication system and IoT devices. The chief intent of telemedicine is delivering a high-quality medical-related service to everyone and from everywhere. The theoretical framework of telemedicine is introduced thirty years and it is delivered to the required patients with the services offered by medical experts. With the support of telecare is offered to the patients through video calls and by other means.

3.2. Monitoring Habitat in Real-Time

The evolution of IoT has enriched the living standard and also improves everyday life. The intruders and eavesdroppers can bug or hack the smart object in the home and controlling pacemakers can risk the life of an individual. The security features are standardized by the incorporation of biometric-based authorization, voice-assisted biometric system, fingerprint scanning, recognition of the face, and retinal authentication system. Public safety is assured by the video surveillance and monitoring system, that is attained by M-IoT and their devices.

With the proliferated distribution of IoT applications in daily life and deterioration in the operational costs, surveillance systems through video became a key prerequisite for the smart city to assure the safety of the public for the detection of crime, ensuring the security credentials of home, surveillance of industries, and other localization-related aspects. The immovability of the PC-based system for the surveillance system inspires the researcher to develop IoT-based security applications. Multimedia communication system over IoT technology permits to accomplish this objective.

3.3. Management of Transportation System

The control and monitoring of traffic is a major issue in most places and the issue is handled by the smart traffic monitoring system. This is formulated by magnetic loops, radars for microwaves, and detectors of infra-red radiation. These conventional frameworks lack accuracy as well as incur huge maintenance and installation cost. Hence, the researcher proposed M-IoT based traffic monitoring approaches that process a huge volume of data, and the reason for the existence of traffic is forecasted.

Real-time traffic and activities on the road are detected by acquiring the information from the number plates.

A multimedia-based web ontology language is utilized for the forecasting of traffic congestion. The unmanned or autonomous are the chief components of the smart city where the obstacles and potholes are identified by processing the images acquired from the context of the real-time road management system. The images and frames acquired from the frames are processed and the needful information is generated from those data. Further, the processed data is utilized in identifying the obstacles in the road, and planning of optimal route is identified from that information is achieved.

The M-IoT system supported with cloud technology is involved in the identification of accidents where the accident identification or accident event report is generated by processing the real-time images. The monitoring system encompasses the recognition of life, subsystem for alarm, and monitoring the environmental condition. Based on the traffic, vehicle movement, and crowd, the traffic or street lights are governed whereas the traffic or street lights are automated based on the context of the traffic. Detection of crime and authorization is needed information is accomplished by information-driven architecture.

3.4. Smart Industry

Industrial IoT is the chief element of smart industry, improves the manufacturing process of the products and the process of the industrial process is optimized. The outcome of the process of the industry is enriched by the characteristics of multimedia information. The production, process, and maintenance of the whole production system are automated with the M-IoT and IloT. The process of automation and ubiquitous computing is established by robotic technology. The context industrial process requires a real-time monitoring system and this is achieved by multimedia communication technology.

The essentials of cultural elements in the museum are the identity of a country and it is a robust identity where the historical knowledge and heritage of culture is preserved. It is the key resource that promotes economic statistics and tourism. The smart museum is considered a huge inspiration for tourism across the world. Agriculture is the backbone of the country's economy and a prominent sector in the industry. Agriculture is revolutionized by the M-IoT that enriches the productivity of agricultural products. The growth of the plant and crops are monitored as well as maintained automatically without the support of human intervention by M-IoT.

Table 2
Detail of different form of M-IOT along with their application and framework

Application			Framework	Year
E-Health Care System	Multimedia based Health Monitoring System		Smart ambulance based on 5G Small cell network [21]	2018
			E-Health based wearable devices with the assistance of M2M communication architecture [22]	2018
			Multimedia aided personal health architecture [23]	2018
			Biomedical data training based on M-IoT [24]	2017
			Robot supported surgery [25]	2017
			Robot supported surgery for fracture using X-ray images [26]	2017
			Remotely monitoring the health care for the cloud of things [27]	2016
			Robotic ambulance service for cardiac arrest [28]	2016
			Smart ocular disease identification [29]	2016
			Retinal cataract identification system using smartphone [30]	2015
Monitoring Habitat in Real-Time	Surveillance of Security System	Authentication System based on Retina	Retina and Iris fusion scanning system for M-IoT[31]	2018
			Authentication of Retina [32]	2015
			Ocular disease identification based on the diminishing effect [33]	2014
			Recognition of face utilizing the retina scan [34]	2014
			Authentication technique based on iris localization [35]	2011
		Authentication System based on Biometric	Biometric-based authentication system based on Industrial IoT[36]	2018
			Biometric IoT[37]	2016
			Secure telecare approach based on Biometric [38]	2014
		Authentication System based on	Secure H-IoT[39]	2019

Application	Voice Assisted Biometric	Framework	Year
Surveillance based Security System		Biometric-based secure IoT[40]	2018
		Voice assisted security system [41]	2018
	Surveillance based Security System	Voice-based biometrics [42]	2017
		Secure mobile based video surveillance approach M-IoT[43]	2018
		Pi camera assisted surveillance system for M-IoT[44]	2018
		Video with multi-view that is compressed by encoding or decoding scheme for M-IoT[45]	2017
		Surveillance system for M-IoT based on video-based indoor positioning system [46]	2017
		Summarization of multi-view video-based on KNN for IoT[47]	2017
		Prevention and monitoring of sudden death of infants [48]	2017
		Summarization of video for smart monitoring system [49]	2017
		Software-defined network-based selection scheme for network technique for the real-time data [50]	2017
		Mechanism of a multi-transport system for M-IoT[51]	2016
		Tracking applications for IoT based on Quadrotors [52]	2016
		Automated selection of the size of the transport block for the transmission of video monitoring across the environment [53]	2016
		Android-based surveillance system for stream and transport protocol [54]	2015
		Summarization of distributed video using IoT[55]	2015
		Vigil based edge computation node for the surveillance of video [56]	2015
		Surveillance of public transportation based on the voice supported ontology-driven system [57]	2009

Application		Framework	Year
		Incorporating parallel processing and slicing the video in IoVT for the M-IoT application [58]	2014
Management of Transportation System	Detection of crime and authentication based on multimedia	Smart city for autonomous taxi [59]	2018
		Payment of toll coset based on IoT [60]	2016
		Detection of crime [61]	2014
		Smart city with efficient network architecture [62]	2012
	Reporting of accidents, lane, and path identification system based on multimedia	Detection of pothole and humps [63]	2018
		Monitoring of vehicles [64]	2018
		Life observation system for vehicles [65]	2018
		Observation of vehicles using android based IoT system [66]	2018
		Detection of accident and surveillance of traffic on the road [67]	2017
		Detection of obstacles using images [68]	2016
		Communication establishment among vehicles [69]	2016
		Planning of path [70]	2011
	Management of traffic lights based on video and image	Guidance scheme for the handling smart city [71]	2018
		Management of lights in the street [72]	2017
	Monitoring of Traffic system	Automated traffic light based on multimedia [73]	2018
		Management of smart traffic [74]	2018
		Management and monitoring of smart traffic for processing the cloud data that is based on mobile multimedia [75]	2018
		Context-aware and ontology-driven image processing system [76]	2017
		Monitoring the smart traffic-utilizing video and image [77]	2017

Application		Framework	Year
Smart Industry		Traffic management using IoV[78]	2017
		Management of traffic using multimedia data via machine to machine communication [79]	2011
	Smart Agriculture using Multimedia Information	Recognition of freshness in the food by utilizing the processing of image with M-IoT [80]	2018
		Monitoring of crop-based on M-IoT in agriculture [81]	2014
		Recognition of food for M-IoT based application [82]	2014
		The production system in agriculture by incorporating M-IoT[83]	2013
		Monitoring the growth of crops by incorporating M-IoT[84]	2012
	Monitoring of Industry using Multimedia Information	Inspection of steel billets by utilizing depth of the vision that is automated[85]	2018
		Conditional observation of petroleum industry [86]	2018
		Inspection of steel billets by modeling with 3D [87]	2017
		Analysis of flame color for the maintenance of combustion [88]	2017
		Recognition and reading of optical character [89]	2016
		Smart grid with sky based energy harvesting scheme [90]	2013
	Image Processing based on Smart Museum	Transportation is established by robots with automated warehouses by incorporating M-IoT application [91]	2018
		Smart museum for the industry by incorporating M-IoT[92]	2017
		Smart museum by utilizing the content delivery by beacon [93]	2017

4. Performance Metrics For M-iot

Multimedia services and applications are highly sensitive to latency and are necessary for an effective network model for preserving the quality of the data. A huge amount of multimedia data proliferates the challenges to meet the requirement of the end-user in the network. The performance of the network is investigated by the user and network-centric metrics. QoS is defined as network-centric and QoE is defined as user-centric where QoE indicates the perception of QoS. This section describes the performance metrics of M-IoT [94].

4.1. Quality of Experience (QoE)

QoE assists in the estimation of the annoyance or delight of the experience of the customer. It mainly emphasizes the whole experience of the service, which is a holistic context and it is identical to the experience of the user.

4.1.1. Mean Opinion Score (MOS)

MOS determines the experience of the user by utilizing the rating in the range of 1 to 5 where the effective experience is represented by 5 and the bad experience is represented by 1. Every MOS is related to every individual session of M-IoT and the experience of every session is investigated by MOS.

4.1.2. Degradation Mean Opinion Score (DMOS)

The service degradation is estimated by the DMOS and it is depicted by the rating of highly annoying as 1 to the inaudible as 5. Satisfaction approach or engagement of user adheres during the interaction with the M-IoT application by the user that is viewing, playtime of video and numerous likes.

4.1.3. Satisfaction of User (SU)

QoE mainly focuses on the estimation of the experience of the user and satisfaction of the user plays a key role in the maximization of the QoE of the user. M-IoT applications have to meet the needs of the user with high satisfaction.

4.2. Quality of Service (QoS)

QoS ensures the overall performance of the M-IoT application and QoS is especially seen by the user satisfaction of the application. Every individual application's performance and functionality are determined by the QoS factors that determine the measurement or description of the application. The quality of service is determined by the factors namely, allocation of bandwidth, packet loss rate, throughput, data rate, selection of route, jitter, and management of the resource.

Allocation of bandwidth, selection of optimal route, and jitter are considered as the objective function of QoS. The process of allocation of frequencies for diverse applications is determined by the bandwidth. Jitter is the diversion between the information transmitted and the duration taken for the transmission. Throughput and loss rate of packet influence more on minimum data rate across the gateways as

associated to high data rate across the gateways in the M-IoT. The optimized selection of route and management of resources across the M-IoT application is determined by the QoS.

5. Conclusion

This article outlines the significance of multimedia information in numerous real-time applications whereas these applications play a prominent role in the integration and processing of data generated by IoT. Based on the inevitability of every distinct application, applicable technology is integrated into the real-time application. M-IoT plays a significant role in monitoring, automating, and process complicated tasks with multimedia information. The patients are monitored in the E-Health care system and it also supports professionals as well as automates the entire process with the help of health multimedia data. Likewise, M-IoT plays a significant role in agriculture, industry, smart city, smart home, security, and traffic management. Every individual application poses an individual role in daily life and attaining effectiveness in the process of automation with the assistance of multimedia data. This research article anticipates various technologies, performance metrics for M-IoT, architectures, and their prominent features in various applications.

Declarations

Ethics Approval and Consent to Participate:

No participation of humans takes place in this implementation process

Human and Animal Rights:

No violation of Human and Animal Rights is involved.

Conflict of Interest: Conflict of Interest is not applicable in this work.

Authorship contributions:

There is no authorship contribution

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References

1. Lee, I., & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons*, 58(4), 431-440.
2. Madakam, S., Lake, V., Lake, V., & Lake, V. (2015). Internet of Things (IoT): A literature review. *Journal of Computer and Communications*, 3(05), 164.
3. Chiang, M., & Zhang, T. (2016). Fog and IoT: An overview of research opportunities. *IEEE Internet of things journal*, 3(6), 854-864.
4. Yassein, M. B., Aljawarneh, S., & Al-Sadi, A. (2017, November). Challenges and features of IoT communications in 5G networks. In *2017 International Conference on Electrical and Computing Technologies and Applications (ICECTA)*(pp. 1-5). IEEE.
5. Zhou, W., Jia, Y., Peng, A., Zhang, Y., & Liu, P. (2018). The effect of iot new features on security and privacy: New threats, existing solutions, and challenges yet to be solved. *IEEE Internet of Things Journal*, 6(2), 1606-1616.
6. Wang, Q., Zhao, Y., Wang, W., Minoli, D., Sohraby, K., Zhu, H., & Occhiogrosso, B. (2017, June). Multimedia IoT systems and applications. In *2017 Global Internet of Things Summit (GloTS)*(pp. 1-6). IEEE.
7. Awan, I., Younas, M., & Naveed, W. (2014, September). Modelling qos in iot applications. In *2014 17th International Conference on Network-Based Information Systems*(pp. 99-105). IEEE.
8. Fizza, K., Banerjee, A., Mitra, K., Jayaraman, P. P., Ranjan, R., Patel, P., & Georgakopoulos, D. (2021). QoE in IoT: a vision, survey and future directions. *Discover Internet of Things*, 1(1), 1-14.
9. Baranwal, G., Yadav, R., & Vidyarthi, D. P. (2020). QoE aware IoT application placement in fog computing using modified-topsis. *Mobile Networks and Applications*, 25(5), 1816-1832.
10. Noura, H., Chehab, A., Sleem, L., Noura, M., Couturier, R., & Mansour, M. M. (2018). One round cipher algorithm for multimedia IoT devices. *Multimedia tools and applications*, 77(14), 18383-18413.
11. Kiran, S., & Sriramoju, S. B. (2018). A Study on the Applications of IOT. *Indian Journal of Public Health Research & Development*, 9(11).
12. Seng, K. P., & Ang, L. M. (2018). A big data layered architecture and functional units for the multimedia Internet of Things. *IEEE Transactions on Multi-Scale Computing Systems*, 4(4), 500-512.
13. Kundur, D., Luh, W., Okorafor, U. N., & Zourntos, T. (2007). Security and privacy for distributed multimedia sensor networks. *Proceedings of the IEEE*, 96(1), 112-130.
14. Susanto, H., & bin Muhaya, F. (2010, May). Multimedia information security architecture framework. In *2010 5th International Conference on Future Information Technology*(pp. 1-6). IEEE.
15. Zhou, L., Xiong, N., Shu, L., Vasilakos, A., & Yeo, S. S. (2010). Context-aware middleware for multimedia services in heterogeneous networks. *IEEE Intelligent Systems*, 25(2), 40-47.
16. Eskicioglu, A. M. (2003). Multimedia security in group communications: recent progress in key management, authentication, and watermarking. *Multimedia Systems*, 9(3), 239-248.
17. Kaeri, Y., Moulin, C., Sugawara, K., & Manabe, Y. (2018). Agent-based system architecture supporting remote collaboration via an internet of multimedia things approach. *IEEE Access*, 6, 17067-17079.

18. Alvi, S. A., Afzal, B., Shah, G. A., Atzori, L., & Mahmood, W. (2015). Internet of multimedia things: Vision and challenges. *Ad Hoc Networks*, 33, 87-111.
19. Rahman, M. A., Hossain, M. S., Hassanain, E., & Muhammad, G. (2018). Semantic multimedia fog computing and IoT environment: sustainability perspective. *IEEE Communications Magazine*, 56(5), 80-87.
20. Rego, A., Canovas, A., Jiménez, J. M., & Lloret, J. (2018). An intelligent system for video surveillance in IoT environments. *IEEE Access*, 6, 31580-31598.
21. Rehman, I. U., Nasralla, M. M., Ali, A., & Philip, N. (2018, October). Small cell-based ambulance scenario for medical video streaming: a 5G-health use case. In *2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT)*(pp. 29-32). IEEE.
22. Ruiz-Zafra, A., Benghazi, K., Mavromoustakis, C., & Noguera, M. (2018, October). An iot-aware architectural model for smart habitats. In *2018 IEEE 16th International Conference on Embedded and Ubiquitous Computing (EUC)*(pp. 103-110). IEEE.
23. Boll, S., Meyer, J., & O'Connor, N. E. (2018). Health media: From multimedia signals to personal health insights. *IEEE MultiMedia*, 25(1), 51-60.
24. de la Borbolla, I. R., Chicoskie, M., & Tinnell, T. (2017, June). Applying the Internet of Things (IoT) to biomedical development for surgical research and healthcare professional training. In *2017 IEEE Technology & Engineering Management Conference (TEMSCON)*(pp. 335-341). IEEE.
25. Ishak, M. K., & Kit, N. M. (2017, November). Design and implementation of robot assisted surgery based on Internet of Things (IoT). In *2017 International Conference on Advanced Computing and Applications (ACOMP)*(pp. 65-70). IEEE.
26. Ma, Y., Dagnino, G., Georgilas, I., & Dogramadzi, S. (2017, June). Automatic tool detection in X-ray images for robotic assisted joint fracture surgery. In *2017 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData)*(pp. 883-887). IEEE.
27. Shah, T., Yavari, A., Mitra, K., Saguna, S., Jayaraman, P. P., Rabhi, F., & Ranjan, R. (2016). Remote health care cyber-physical system: quality of service (QoS) challenges and opportunities. *IET Cyber-Physical Systems: Theory & Applications*, 1(1), 40-48.
28. Samani, H., & Zhu, R. (2016). Robotic automated external defibrillator ambulance for emergency medical service in smart cities. *IEEE Access*, 4, 268-283.
29. Yin, F., Lee, B. H., Yow, A. P., Quan, Y., & Wong, D. W. K. (2016, December). Automatic ocular disease screening and monitoring using a hybrid cloud system. In *2016 IEEE international conference on Internet of Things (iThings) and IEEE green computing and communications (GreenCom) and IEEE cyber, physical and social computing (CPSCom) and IEEE smart data (SmartData)*(pp. 263-268). IEEE.
30. Kaur, M., Kaur, J., & Kaur, R. (2015, October). Low cost cataract detection system using smart phone. In *2015 International Conference on Green Computing and Internet of Things (ICGCIoT)*(pp. 1607-1609). IEEE.

31. Parizi, R. M., Dehghantanha, A., & Choo, K. K. R. (2018, August). Towards better ocular recognition for secure real-world applications. In *2018 17th IEEE International Conference On Trust, Security And Privacy In Computing And Communications/12th IEEE International Conference On Big Data Science And Engineering (TrustCom/BigDataSE)*(pp. 277-282). IEEE.
32. Pjatin, K., Daneshmand, M., Rasti, P., & Anbarjafari, G. (2015, January). Probability distribution function based iris recognition boosted by the mean rule. In *Proceedings of 2015 International Conference on Intelligent Computing and Internet of Things*(pp. 47-50). IEEE.
33. Waheed, Z., Akram, M. U., Waheed, A., & Shaukat, A. (2015, November). Robust extraction of blood vessels for retinal recognition. In *2015 Second international conference on information security and cyber forensics (InfoSec)*(pp. 1-4). IEEE.
34. Cheng, Y., Jiao, L., Li, Z., & Cao, X. (2014, October). An improved retinal modeling for illumination face recognition. In *2014 IEEE International Conference on Image Processing (ICIP)*(pp. 244-247). IEEE.
35. Zhang, Z., Li, M., Xia, F., & Ma, J. (2011, October). An improved iris localization method for authentication system. In *2011 International Conference on Internet of Things and 4th International Conference on Cyber, Physical and Social Computing*(pp. 663-666). IEEE.
36. Das, A. K., Wazid, M., Kumar, N., Vasilakos, A. V., & Rodrigues, J. J. (2018). Biometrics-based privacy-preserving user authentication scheme for cloud-based industrial Internet of Things deployment. *IEEE Internet of Things Journal*, 5(6), 4900-4913.
37. Al-Alem, F., Alsmirat, M. A., & Al-Ayyoub, M. (2016, November). On the road to the Internet of Biometric Things: A survey of fingerprint acquisition technologies and fingerprint databases. In *2016 IEEE/ACS 13th International Conference of Computer Systems and Applications (AICCSA)*(pp. 1-6). IEEE.
38. Maitra, T., & Giri, D. (2014). An efficient biometric and password-based remote user authentication using smart card for telecare medical information systems in multi-server environment. *Journal of medical systems*, 38(12), 1-19.
39. Hamidi, H. (2019). An approach to develop the smart health using Internet of Things and authentication based on biometric technology. *Future generation computer systems*, 91, 434-449.
40. Obaidat, M. S., Rana, S. P., Maitra, T., Giri, D., & Dutta, S. (2019). Biometric security and internet of things (IoT). In *Biometric-Based Physical and Cybersecurity Systems*(pp. 477-509). Springer, Cham.
41. Meng, Y., Zhang, W., Zhu, H., & Shen, X. S. (2018). Securing consumer IoT in the smart home: Architecture, challenges, and countermeasures. *IEEE Wireless Communications*, 25(6), 53-59.
42. Boles, A., & Rad, P. (2017, June). Voice biometrics: Deep learning-based voiceprint authentication system. In *2017 12th System of Systems Engineering Conference (SoSE)*(pp. 1-6). IEEE.
43. Al-Saleh, M. I., Alsmirat, M. A., Jararweh, Y., & Obaidat, I. (2018, October). A unified key distribution and session management protocol for mobile video surveillance systems. In *2018 Fifth International Conference on Internet of Things: Systems, Management and Security*(pp. 234-238). IEEE.
44. Basri, A. H., Ibrahim, S. N., Malik, N. A., & Asnawi, A. L. (2018, September). Integrated surveillance system with mobile application. In *2018 7th International Conference on Computer and Communication Engineering (ICCCE)*(pp. 218-222). IEEE.

45. Cen, N., Guan, Z., & Melodia, T. (2017). Interview motion compensated joint decoding for compressively sampled multiview video streams. *IEEE Transactions on Multimedia*, 19(6), 1117-1126.
46. Chen, L. W., Chen, C. R., & Chen, D. E. (2017, March). VIPS: A video-based indoor positioning system with centimeter-grade accuracy for the IoT. In *2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops)*(pp. 63-65). IEEE.
47. Lin, S. T., Liao, Y. H., Tsao, Y., & Chien, S. Y. (2017, May). Object-based on-line video summarization for internet of video things. In *2017 IEEE International Symposium on Circuits and Systems (ISCAS)*(pp. 1-4). IEEE.
48. Liu, X., Takeuchi, K., Ogunfunmi, T., & Mathapathi, S. (2017, October). Video-based IoT baby monitor for SIDS prevention. In *2017 IEEE Global Humanitarian Technology Conference (GHTC)*(pp. 1-7). IEEE.
49. Thomas, S. S., Gupta, S., & Subramanian, V. K. (2017, July). Smart surveillance based on video summarization. In *2017 IEEE Region 10 Symposium (TENSymp)*(pp. 1-5). IEEE.
50. Baidya, S., & Levorato, M. (2017, May). Edge-assisted content and computation-driven dynamic network selection for real-time services in the urban IoT. In *2017 IEEE conference on computer communications workshops (INFOCOM WKSHPS)*(pp. 796-801). IEEE.
51. Silva, H., & Neto, A. (2016, December). A holistic SDN-capable session-plane tailored for efficient IoMT smart surveillance applications. In *2016 IEEE Globecom Workshops (GC Wkshps)*(pp. 1-6). IEEE.
52. Kougianos, E., Mohanty, S. P., Coelho, G., Albalawi, U., & Sundaravadivel, P. (2016). Design of a high-performance system for secure image communication in the internet of things. *IEEE Access*, 4, 1222-1242.
53. Tsai, W. C., Huang, N. T., & Tsai, T. M. (2016, July). An automatic TBS index selection scheme for video transmission over narrow band cellular IoT. In *2016 International Conference on Machine Learning and Cybernetics (ICMLC)*(Vol. 2, pp. 697-703). IEEE.
54. Fan, B., Pan, G., Liu, M., & Li, C. (2015, August). Design of a home surveillance system based on the Android platform. In *2015 12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD)*(pp. 2101-2105). IEEE.
55. Ou, S. H., Lee, C. H., Somayazulu, V. S., Chen, Y. K., & Chien, S. Y. (2015, June). Video sensor node with distributed video summary for Internet-of-Things applications. In *2015 IEEE International Conference on Consumer Electronics-Taiwan*(pp. 304-305). IEEE.
56. Zhang, T., Chowdhery, A., Bahl, P., Jamieson, K., & Banerjee, S. (2015, September). The design and implementation of a wireless video surveillance system. In *Proceedings of the 21st Annual International Conference on Mobile Computing and Networking*(pp. 426-438).
57. QasemiZadeh, B., Shen, J., O'Neill, I., Miller, P., Hanna, P., Stewart, D., & Wang, H. (2009, September). A speech based approach to surveillance video retrieval. In *2009 Sixth IEEE International Conference on Advanced Video and Signal Based Surveillance*(pp. 336-339). IEEE.

58. Ting, W. C., Lu, K. H., Lo, C. W., Chang, S. H., & Liu, P. C. (2014, September). Smart video hosting and processing platform for Internet-of-Things. In *2014 IEEE International Conference on Internet of Things (iThings), and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom)*(pp. 169-176). IEEE.
59. Rajput, N. S., Mishra, A., Sisodia, A., & Makarov, I. (2018, February). A novel autonomous taxi model for smart cities. In *2018 IEEE 4th World Forum on Internet of Things (WF-IoT)*(pp. 625-628). IEEE.
60. Pašalić, D., Cvijić, B., Bundalo, D., Bundalo, Z., & Stojanović, R. (2016, June). Vehicle toll payment system based on Internet of Things concept. In *2016 5th Mediterranean Conference on Embedded Computing (MECO)*(pp. 485-488). IEEE.
61. Byun, J. Y., Nasridinov, A., & Park, Y. H. (2014). Internet of things for smart crime detection. *Contemporary Engineering Sciences*, 7(15), 749-754.
62. Jin, J., Gubbi, J., Luo, T., & Palaniswami, M. (2012, October). Network architecture and QoS issues in the internet of things for a smart city. In *2012 International Symposium on Communications and Information Technologies (ISCIT)*(pp. 956-961). IEEE.
63. Chellaswamy, C., Famitha, H., Anusuya, T., & Amirthavarshini, S. B. (2018, March). IoT based humps and pothole detection on roads and information sharing. In *2018 International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC)*(pp. 084-090). IEEE.
64. Chellaswamy, C., Famitha, H., Anusuya, T., & Amirthavarshini, S. B. (2018, March). IoT based humps and pothole detection on roads and information sharing. In *2018 International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC)*(pp. 084-090). IEEE.
65. Ni, F., Wei, J., & Shen, J. (2018, October). An Internet of Things (IoTs) based intelligent life monitoring system for vehicles. In *2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*(pp. 532-535). IEEE.
66. Türk, E., & Challenger, M. (2018, May). An android-based IoT system for vehicle monitoring and diagnostic. In *2018 26th Signal Processing and Communications Applications Conference (SIU)*(pp. 1-4). IEEE.
67. Patel, R., Dabhi, V. K., & Prajapati, H. B. (2017, April). A survey on IoT based road traffic surveillance and accident detection system (A smart way to handle traffic and concerned problems). In *2017 Innovations in Power and Advanced Computing Technologies (i-PACT)*(pp. 1-7). IEEE.
68. Reddy, G. V. P., & Nagaraja, S. R. (2016, December). Image based obstacle detection and path planning for solar powered autonomous vehicle. In *2016 International Conference on Robotics and Automation for Humanitarian Applications (RAHA)*(pp. 1-7). IEEE.
69. Reddy, G. V. P., & Nagaraja, S. R. (2016, December). Image based obstacle detection and path planning for solar powered autonomous vehicle. In *2016 International Conference on Robotics and Automation for Humanitarian Applications (RAHA)*(pp. 1-7). IEEE.
70. Baek, J. Y., Kim, S. H., & Lee, M. C. (2010, August). Path planning of unmanned vehicle using potential field and lane detection. In *Proceedings of SICE Annual Conference 2010*(pp. 1339-1342). IEEE.

71. Latif, S., Afzaal, H., & Zafar, N. A. (2018, March). Intelligent traffic monitoring and guidance system for smart city. In *2018 International Conference on Computing, Mathematics and Engineering Technologies (iCoMET)*(pp. 1-6). IEEE.
72. Saifuzzaman, M., Moon, N. N., & Nur, F. N. (2017, December). IoT based street lighting and traffic management system. In *2017 IEEE region 10 humanitarian technology conference (R10-HTC)*(pp. 121-124). IEEE.
73. George, A. M., George, V. I., & George, M. A. (2018, March). IoT based smart traffic light control system. In *2018 International Conference on Control, Power, Communication and Computing Technologies (ICCPCT)*(pp. 148-151). IEEE.
74. Avatefipour, O., & Sadry, F. (2018, May). Traffic management system using IoT technology-A comparative review. In *2018 IEEE International Conference on Electro/Information Technology (EIT)* (pp. 1041-1047). IEEE.
75. Celesti, A., Galletta, A., Carnevale, L., Fazio, M., Lay-Ekuakille, A., & Villari, M. (2017). An IoT cloud system for traffic monitoring and vehicular accidents prevention based on mobile sensor data processing. *IEEE Sensors Journal*, 18(12), 4795-4802.
76. Goel, D., Pahal, N., Jain, P., & Chaudhury, S. (2017, July). An ontology-driven context aware framework for smart traffic monitoring. In *2017 IEEE Region 10 Symposium (TENSYP)*(pp. 1-5). IEEE.
77. Lah, A. A. A., Latiff, L. A., Dziyauddin, R. A., Kaidi, H. M., & Ahmad, N. (2017, December). Smart traffic monitoring and control architecture and design. In *2017 IEEE 15th Student Conference on Research and Development (SCoReD)*(pp. 72-76). IEEE.
78. Dandala, T. T., Krishnamurthy, V., & Alwan, R. (2017, January). Internet of Vehicles (IoV) for traffic management. In *2017 International conference on computer, communication and signal processing (ICCCSP)*(pp. 1-4). IEEE.
79. Foschini, L., Taleb, T., Corradi, A., & Bottazzi, D. (2011). M2M-based metropolitan platform for IMS-enabled road traffic management in IoT. *IEEE Communications Magazine*, 49(11), 50-57.
80. Witjaksono, G., Rabih, A. A. S., btYahya, N., & Alva, S. (2018, March). IOT for agriculture: food quality and safety. In *IOP Conference Series: Materials Science and Engineering*(Vol. 343, No. 1, p. 012023). IOP Publishing.
81. Nisha, G., & Megala, J. (2014, December). Wireless sensor Network based automated irrigation and crop field monitoring system. In *2014 Sixth international conference on advanced computing (IcoAC)* (pp. 189-194). IEEE.
82. Yanai, K., Maruyama, T., & Kawano, Y. (2014). A Cooking Recipe Recommendation System with Visual Recognition of Food Ingredients. *International Journal of Interactive Mobile Technologies*, 8(2).
83. Lee, M., Hwang, J., & Yoe, H. (2013, December). Agricultural production system based on IoT. In *2013 IEEE 16Th international conference on computational science and engineering*(pp. 833-837). IEEE.
84. Lee, J., Kang, H., Bang, H., & Kang, S. (2012, October). Dynamic crop field analysis using mobile sensor node. In *2012 International Conference on ICT Convergence (ICTC)*(pp. 7-11). IEEE.

85. Hsu, C. Y., Kang, L. W., Lin, H. Y., Fu, R. H., Lin, C. Y., Weng, M. F., & Chen, D. Y. (2018, April). Depth-based feature extraction-guided automatic identification tracking of steel products for smart manufacturing in steel 4.0. In *2018 IEEE International Conference on Applied System Invention (ICASI)*(pp. 145-146). IEEE.
86. Gore, R. N., Kour, H., & Gandhi, M. (2018, January). IoT based equipment identification and location for maintenance in large deployment industrial plants. In *2018 10th International Conference on Communication Systems & Networks (COMSNETS)*(pp. 461-463). IEEE.
87. Hsu, C. Y., Lin, H. Y., Kang, L. W., Weng, M. F., Chang, C. M., & You, T. Y. (2017, June). 3D modeling for steel billet images. In *2017 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW)*(pp. 5-6). IEEE.
88. Sujatha, K., Bhavani, N. P., Reddy, T. K., & Kumar, K. R. (2017, January). Internet of things for flame monitoring power station boilers. In *2017 Trends in Industrial Measurement and Automation (TIMA)* (pp. 1-7). IEEE.
89. Kulkarni, P. H., Kute, P. D., & More, V. N. (2016, January). IoT based data processing for automated industrial meter reader using Raspberry Pi. In *2016 International Conference on Internet of Things and Applications (IOTA)*(pp. 107-111). IEEE.
90. Yao, R., Wang, W., Farrokh-Baroughi, M., Wang, H., & Qian, Y. (2013). Quality-driven energy-neutralized power and relay selection for smart grid wireless multimedia sensor based IoTs. *IEEE Sensors Journal*, 13(10), 3637-3644.
91. G. Plaksina, G. I. Chistokhina and D. V. Topolskiy, "Development of a Transport Robot for Automated Warehouses," in *IEEE International Multi-Conference on Industrial Engineering and Modern Technologies*, Vladivostok, Russia, 2018.
92. Sornalatha and V. R. Kavitha, "IoT Based Smart Museum using Bluetooth Low Energy," in *IEEE International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics*, Chennai, India, 2017.
93. A. S. Rao, A. V. Sharma and C. S. Narayan, "A Context Aware System for an IoT-Based Smart Museum," in *IEEE International Multidisciplinary Conference on Computer and Energy Science*, Split, Croatia, 2017.

Figures

Figure 1

Important features and significance of IoT

Figure 2

M-IoT architecture