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Multimedia Computing and Internet of Things Applications: A Taxonomy and Challenges

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ABSTRACT

With a rapid growth of multimedia devices over the Internet of Things (IoT) technology, a huge amount of multimedia data would be generated which is also called as multimedia big data. The Internet of Things systems cannot successfully realize the connectivity of multimedia devices if they are not able to process the multimedia devices at once, on the other hand trending research and development actions focusing on scaling methods for sensor data which is generated from several IoT devices. However, the current development activities and research do not mandate the characteristics of connectivity among multimedia objects and leaving a research gap, the advantages from multimedia based services and applications. In this paper, focused on this issue by contemplating the idea of Internet of Things and focusing an advantages towards the vision of Internet of Multimedia Things (IoMMT). This paper investigates the taxonomy of multimedia bigdata computing and IoT applications and also focused on challenges from the multimedia computing methods and IoT applications. This comprehensive taxonomy model addresses a number of research challenges associated with multimedia things (MMT), such as heterogeneity, accessibility, scalability and reliability and Quality of Service requirements.

1. Introduction

The rapid growth of computing services and applications offered by the internet have huge wide the span of the global network. Presently, over 12 billion network devices are interconnected to the internet offering services more than 3 billion people around the world for communication such as chat rooms, blogs, social networks, books, games, music, shopping, videos and emails. To share the knowledge throughout the globe, services offers like encyclopedia, e-books and education. The recent advanced approaches in designing low cost multimedia devices, giving opportunities to enable the advanced technologies in real-time world. The huge growth of multimedia devices is estimated over the next ten years. So, all devices around us will able to get the capability to communicate with other, e.g. mobile devices, laptops and desktop computers etc. Figure 1, presents the usage of internet across the globe. Year by year, the internet usage growth rate is increasing very fast. Such as web usage, files sharing and video streaming services taking more percentage in the usage of internet. Smart multimedia devices existed with the ability to observe the physical environment and at the same time they have the capabilities to interact with environments, this idea towards the smart intelligence in the physical environment.

Internet of Things, Kevin Ashton was considered as the former of the concept of IoT [1]. Since, the IoT has developed very fast from the personal guest room to the large industry floor by either using ordinary technology like Wireless sensor network (WSN), Radio frequency identification (RFID), Bluetooth and additionally taking advantage of the cloud computing technology. The whole architecture offered a smart city including clean living environment, smart home and smart vehicles. The word of internet of things is a simple concept that internet network develops from a way for multimedia devices to become smart intelligence and connected each multimedia device with other multimedia device [2]. These all interconnected devices are able to gather processing data and makes the appropriate decisions. Based on the International data corporation (IDC), the IoT is an interconnected network of multiple networks of uniquely identifiable access points or identifiable things, which are communicate with other devices without human interaction using IP network connectivity. The IoT research forum of 2016 forecasted that there is a large market for IoT developments growing from $3.1 trillion in 2015 to $7.5 trillion in 2020.

Additionally, the IoT technology taking the advantages of cloud computing technology to process the data which is collected from several devices such as sensors and multimedia devices. In addition, by using fog computing and edge computing technologies [3] offers most cutting edge network in the view of processing collected data. This vision gives a big step towards new demand communication vision. To be more particularly, to get smarter in connected network, there are rising difficulties such as data storage, scalability, reliability, heterogeneous resource environment, energy saving and data processing. With the help of fog computing and edge computing [4], the above challenges are reducing, but not a completely. With the lack of efficient resource management, multimedia devices data generates several difficulties. To address these challenges, Internet of multimedia things delivers the new services which are useful for resource management challenges.

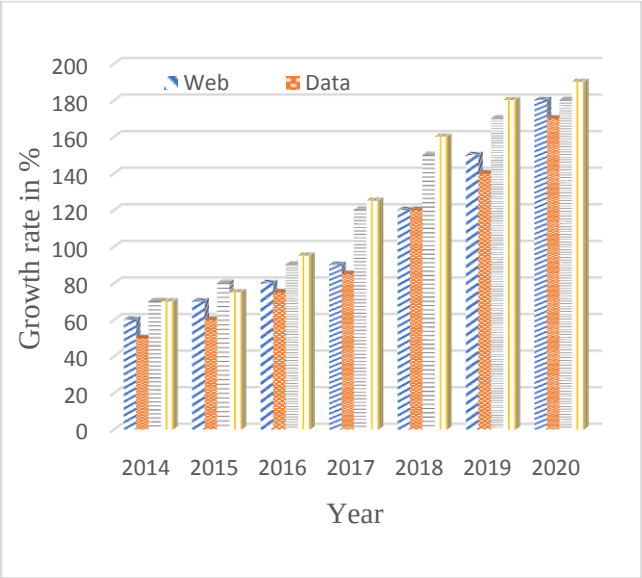

Fig 1: Global internet traffic usage and prediction

In an IoT based systems, action triggering and intelligence capabilities is embedded in the multimedia devices with the help of actuators and sensors. Similarly, a cloud computing technology gives the capability to develop, maintain and processing several services by computing services and storage resources. So that, users are allowed to monitor and control the multimedia devices from any place at any time. Multimedia devices communication in wireless sensors networks [5] have mentioned in many surveys, but with limited topics that is application specific, device specific and content specific. But those surveys were not focused on the architecture of Internet of multimedia things which gives the solutions for heterogeneity multimedia device environment, communication among multimedia devices, complex multimedia processing data, bandwidth issues of multimedia devices and cloud service issues. The main goal of this paper is to develop the efficient architecture of Internet of multimedia things and characteristics of internet of multimedia things are analyzed thoroughly. Additionally, discussed about comparisons among existing systems. Moreover, a review is done about existing technologies which is guidance for the realization of Internet of multimedia things based systems.

The rest of the paper is organized as follows. Section 2, presents about background work of Internet of Things and multimedia computing. Section 3, focuses on challenges of Internet of Things in the view of multimedia devices. In section 4, focuses on multimedia sensing vision with new requirements and multimedia data stream communication. Finally, Section 5 concludes the taxonomy and challenges of multimedia computing in Internet of Things.

2. Internet of Multimedia Things (IoMMT)

The Internet of Things systems have been developed recently and many features in wireless sensor networks has to be revised in order to fully integrate multimedia devices in the IoT technology. Figure 2, presents an architecture of IoT as also tackled by the IoT European research project [6]. In this architecture at each layer performs the services and functionalities to offer the services to users. At first layer, all multimedia devices are connected with each other under a network and share the data with other to take appropriate decision by each multimedia device. The next layer, IoT services and resource layer provides the search and discovery functionalities. By using this feature, each and every multimedia device provide data to a single specific device instead of restriction. At this layer, IoT services and resources shares with each device which are interconnected to network and on the other hand, devices maintains resource history storage details and service resolutions. In next layer, virtual entities are introduces with the main aim of counterpart of the physical devices. These virtual devices can be useful for efficient resource management in IoT network and virtual resources shares the storage memory with each device which are interconnected to network and on the other hand, virtual devices maintains resource history storage details and service monitoring. In the next layer, service will be executed and orchestration. All processing functionalities will be executed at this layer for processing multimedia device data. In the final layer, applications will provide the information to users. From bottom to top, collected data will be processed and sending to further layers. Finally, application user will receive the information at application layer which is works like user interface panels.

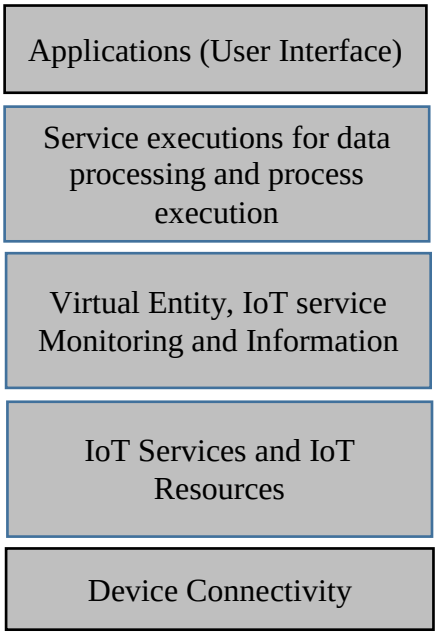

Fig 2: IoT architecture in the view of processing

Multimedia computing has an extensive range of Internet of Things applications, for healthcare, for instance, for satellite imaging and smart nations [2]. Particularly, this section provide the information about advanced complexity of multimedia computing for IoT systems to be acts like intelligence and to optimize the storage, communication and computing. Multimedia computing for IoT applications is new, which is partly increases in the range of smart sensing multimedia devices and multimedia applications.

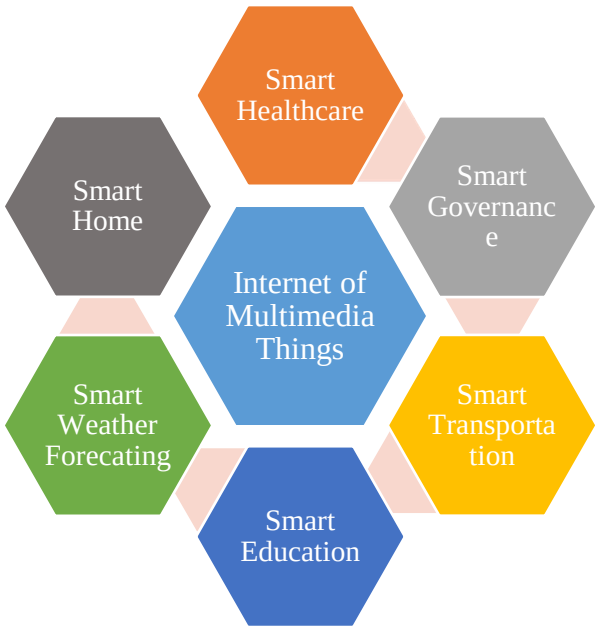

Fig 3: Multimedia Applications for Internet of Multimedia Things

2.1 Healthcare Applications

Multimedia computing is transforming medical field, finance, healthcare, science, business and engineering. Increasing difficulties on healthcare problems motivating develops low weight and small sized wearable real time sensors for uninterrupted physical examination. Several data is collected from multimedia devices and sensors is transported to gadget such as smart phones or tablets. This data is transferred to cloud for processing and stored to maintain health documentation services. So, developing intelligence multimedia devices in the view of IoT systems is very important things for solving the issues.

2.2 Smart Cities

Smart cities enhance working process, life and travel. Intelligence devices plays a key role in smart cities. This type of technology improves the cities and provides smart services such as traffic services, children services, social care services, public safety, home services and medical care services. There are several difficult services could be solved by IoT systems with low-cost budget. Smart homes can be monitored from anywhere at any time, for example fire accidents can be monitored, children activities and unknown person activities can be monitored. Smart parking also makes flexible for various vehicles. By using these technology new parking slots can be recognized automatically.

2.3 Surveillance Systems

Physical environment security is a crucial thing for children's, women and senior citizens. To solve the issues arising from surveillance systems, smart city technology can reduce the problems. In multimedia computing process, collected data can be analyzed and detecting critical and crime tasks. For example, video sensor networks are very useful for smart cities, smart homes, video surveillance and environment monitoring. At the same time in video sensor networks, power efficiency is the very important parameter of energy node resources.

2.4 Smart Education and Smart Governance

Education and governance are generating huge amount of multimedia data continuously and computing process has to analyze to maintain the standard information. The concept of smart city includes the good governance which can be developed by smart technology and smart education. In IoT systems, sensor devices collects the data from the students and employees in educational organizations and government organizations. For example when vehicle met with accident, the video of the accidental condition pass through the IoT network then give alert and emergency service.

Figure 3, presents the major advantages of Internet of Multimedia Things which is major applications of a middleware platform. This architecture involved with multimedia connected devices generation and the complexity. Smart intelligence systems makes the flexibility in real-time world and providing more benefits users daily life.

3. Taxonomy for Multimedia computing for IoT Systems

The taxonomy of multimedia computing in IoT systems is presented in this section. The taxonomy describes the processing methods which are following in IoT systems. The comprehensive taxonomy for Internet of Multimedia Things presented in figure 4.

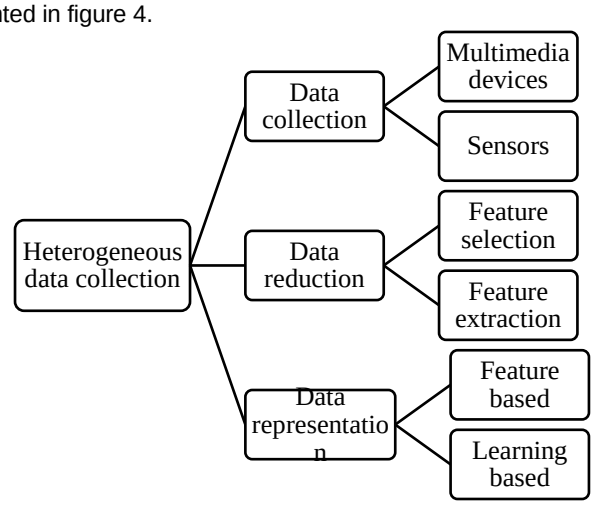

Fig 4: Multimedia computing for IoT Systems

As shown in the figure 4, the taxonomy is presented with three important stages, such as data collection, data reduction and data representation. At first stage, data is collected from several devices which is called heterogeneous data collection. From this collection, suitable data will be collect at data collection stage. The second stage is data reduction, huge data creates ambiguous in decisions. So by using feature selection and feature extraction algorithms [7] can be removed the unnecessary data. With the help of machine algorithms [8], unnecessary data will be removed from collected data. Final stage is data representation, at this stage data can be represented in two ways such as feature based data and learning based data. This learning based data is concern as a historical data which can be used for further processing purpose.

3.1 Data Collection

In the IoT systems, data collection often occurs through monitoring of sensors; enhancing data collection in this process has been developed in various environments including the context of predicting involving epidemiological behavior change. Along with sensors, IoT multimedia device collection features have extended through development of wireless sensors networks and personal multimedia devices with image and video technology developments and are rapidly interconnected with persons to persons instead of organizations. Such unique data is also collected by advanced sensors that acts as an important source of multimedia computing process and offers 24 * 7 data streams. Therefore, multimedia computing for IoT device collection approaches are different in nature and extended to evolve with device, sensor, media technology and network.

3.2 Data Reduction

During the data reduction process of multimedia computing, the data volume must be reduced. The multimedia computing reduction refers to sampling dataset so that it can be analyzed using very limited computing resources with several technologies. The reduction refers to size reduction of collected data. It is a method helps in reducing various source collected data through various device processing methods. These methods include compressive sensing and wavelet transform to compress multimedia computing data. Sharkh et al. [18] addressed a solution for reduction sensing method for analyzing, transporting and storing large sets of data gathered from high-resolution multimedia devices and the Internet sources. The wavelet transform based data reduction methods has been described by Bui et al. [19]. It can hold potentially huge and difficult complex curves of data. This approach reduces the objective functions to change the adjustment between data reduction and accuracy of data modeling. The optimization approaches and the large scattering of collected data forecasted the threshold limit values according to the theoretic studies.

3.2.1 Feature Selection and Feature Extraction

Feature selection process is a generation of features from data sources that are in a format, so that it is difficult to analyze directly and comparison is very difficult such as time series and images. For example, in time series, few simple features taken for example such as standard deviations, mean, period and length of time-series etc. This conversion of existing features in order to create new ones based on the historical feature datasets. This model is used the technique for feature reduction is Principal Component Analysis which is called PCA that uses some linear transformation in order to develop a set of linearly non-correlated variables based on the initial set of variables. Selection of the features with the highest importance on the target variable, from a set of existing features.

3.3 Data Representation

Data generated over multimedia devices are presented by means of a hierarchical structure called as data representation so that it can be modeled for subsequent analysis. When the data sources are several, it has a propensity for different presentations or common presentation for each multimedia source to operate the multimedia computing analysis. Such conversion can be elaborated by descriptive metadata and structural approaches. The scale invariant feature extraction is a kind of feature based presentation useful for multimedia computing presentations.

3.3.1 Feature based representation

Multimedia computing process is intellectually multi model in technology, usually it is a regular feature is used to represent multimedia devices collected data, called as feature based data representation. In this method, the good representation of the multimedia devices collected data, is collected among all possible correlations of features. L.N. Sun et al. [5] addressed the solution is a multi-model feature learning approach based on artificial neural network based approaches, for example, Auto-encoders, De-noising and Skip-gram. It addresses to the blogging content using web sentiment analysis. For example, short messages on different applications like twitter, WhatsApp etc., which are created by a short text or by an image. This proposed approach can be categorized into two parts, such as training language approaches that presented to be high performance and good effective when processing using web integration text bodies with semantic and syntactic word similarities. Machine learning of approaches model features, which are recoverable from mathematical interpretations that due to effectively changes picture format and reduce noise in the data collections. This method addressed effective classification results and efficient to use.

3.3.2 Learning based representation

A regular feature is very difficult to search in large data collection maintains from heterogeneous data sources such as IoT multimedia devices. To solve these type of issues, an effective method would be to find hierarchical hidden hypothesis space with in multi-model and heterogeneous devices data. Different kind of machine learning methods have been addressed the solutions previously for multimedia computing process presentation. For example deep learning techniques such as deep auto encoder and deep boltzmann machines are few of the deep learning methods used to carry out multimedia computing presentation. They are developed deep learning techniques to learn high-level presentations through low-level structures like non-linear methods to complete a different kind of tasks. Sahni et al. [4] addressed solution with help of machine learning model that exits various and different input models. This machine learning model had been used to extract features abstracted that fuses models to each other. This technique is used for features retrieval cataloging and tasks. The proposed model worked on likelihood dataset using multi model inputs. The proposed model worked very well by sampling from the conditional distribution data and take out the presentation for other models which are missing. Also, it is useful for feature extraction from various datasets.

4. Challenges for Multimedia Computing and IoT Applications

This section describes the challenges of multimedia computing in IoT systems such as smart cities, smart health care and smart intelligence devices. These challenges are arising in the view of storage as well as processing data for IoMMT. Rapid growth in IoT technology generates a huge amount of data frequently at an exponential rate. However, many processing analytic approaches are available for

analyzing the collected data. But limited processing analytic approaches could not be address efficiency scaling methods. Few challenges are discussed about multimedia IoT applications.

4.1 Heterogeneity environment data

The main challenges of the multimedia computing in IoT systems is, data is collected from various devices. After collecting data from several devices, data would be send to analytical section. This section analyze the data then gives the information for users. But handling various types of data is a challenging task. For example, currently Map-reduce technique is using for processing the collected data.

4.2 Storage of collected data

The issue of the storage is based on the hierarchical storage of the system. That means, collected data stores in hierarchical manner for processing purpose. Currently IoT systems sending the collected data to cloud technologies for processing purpose. Because of rapid data from several devices, cloud technology face the problem of energy optimization. This issue is one of the big challenging tasks for power optimization.

4.3 Algorithms

Algorithms plays important role in multimedia computing process. Each algorithm increase the performance of the deployed architecture. Because arriving stream data from different types of data creates ambiguous issues. By using efficient algorithms data can be processes effectively. But lack of the appropriate algorithms this analysis takes much time and it turns as a complex task. So, efficient algorithms can increase the performance of the IoT system network.

4.4 Security and Privacy

Several security and privacy policies should be concern so that the individual information of other users could not b take without owner permission. To protect the data which is collected from several users should be protect from attackers and it should not be misused. The IoT system has to adopt the secure key management techniques to protect the data.

5. Conclusion and Future trends

The existing methods for multimedia communication have a huge variety of IoT applications, including satellite imaging, smart environments, healthcare, and smart cities. For effective analysis, need effective and efficient algorithms, for processing and storage approaches that address the challenges described in this paper. Based on these issues, presented a paper on the sources of multimedia computing in the IoT system. And also discussed different challenges in the view of processing. Reviewed literature covering scalability, measurements, accessibility, data fortification, data reliability, data features, data alteration, confidentiality, proper to use of data, and authority. Highlighted the issues of multimedia computing in IoT systems and presented a taxonomy. The taxonomy, described a higher level process model that is an extended multimedia computing considering multimedia computing for IoT devices. Finally, presented a challenges to demonstrate the multimedia computing process model.

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