International Journal on Future Revolution in Computer Science & Communication Engineering
Volume: 4 Issue: 3
ISSN: 2454-4248
45 – 48

Applications of Emotion Recognition for IoT

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***Abstract*—** With the tremendous growth in the field of Artificial Intelligence, the technology has to be user-centric. The devices would respond and behave according to the human moods. Facial expressions are best way to predict the mood/emotion of the person without wearing monitoring devices and sensors. With advancement in Emotion Sensing Technology(EST), emotion recognition has vast number of applications in the field of Internet of Things (IoT) ranging from controlling home devices to Patient Monitoring System. In this paper, various applications of Emotion Recognition in the field of Internet of Things (IoT) are discussed to get an insight of the current and future trends.

Keywords- *Facial Expression Recognition, Emotion Recognition, IoT, Emotion Sensing Technology*

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I. INTRODUCTION

Artificial Intelligence has become the most growing field in the subject of computer science due to its vast applications in different fields. The machines are exhibiting the intelligence similar to that of a human being. A typical AI device follows the process of learning, reasoning and self-correction. Various applications of the Artificial Intelligent system are applied in Speech Recognition, Automotive, Healthcare, Computer Vision, Smart Devices, Gaming, Robotics and many more.

A. IoT (Internet of Things)

IoT is the most talked term in the recent years. Although the devices have already been communicating with each other since the 1830s and 1840s, the term IoT (Internet of things) is coined by Kevin Ashton, executive director of the Auto-ID Center. IoT has gained great popularity due to vision towards the Smart World which comprises of smart devices, smart homes, smart cars, smart cities etc. According to Gartner report, 20.6 billion will be connected across all technologies by 2020.

Various applications of IoT are shown in Figure 1 below:

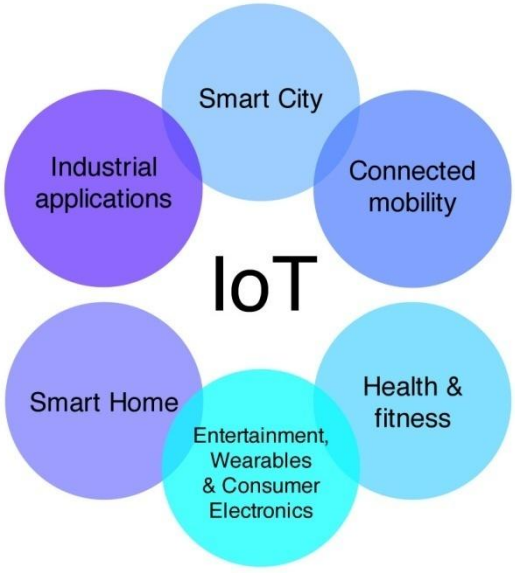

Figure 1. IoT Applications

Apart from these, the applications include:

- Smart Energy and Smart Grid
- Smart Transportation
- Smart Manufacturing
- Smart Environment
- IoT in Agriculture
- Smart Animal Farming

IoT makes all the devices connected to each other via internet so that they can communicate with/without human interference. Since most of the devices used in the IoT are wireless so power/energy efficiency becomes the major issue. All the devices connected to each other have a unique address for the identification. These devices exchange information with each other and take relevant actions autonomously. For the collaboration, IoT devices are equipped with embedded sensors, processors, and transceivers. Sensors receive the data from the physical environment. Various examples of sensors are movement sensor, light sensor, location sensor, proximity sensor. RFID (Radio-frequency identification) sensors and WSN(Wireless Sensor Network) sensors play the major role in the sensing of data from physical environment. The information gathered from all the sensors is converted into the digital signal for better transmission. As huge amount of data is collected by the sensor devices, compute and storage resources are required to analyze, store, and process this data[1]. The Network layer processes the data gathered from the sensing layer and transfers the data through Wireless Network, Bluetooth, Zigbee etc. The heterogeneity of the devices is handled by the service layer. Cloud infrastructure is used to handle the large number of sensing devices. Interface Layer works at the front-end. It provides the applications specific to the industry such as manufacturing, retail, healthcare etc. Security of data is important at every layer. The communication between the layers has to be real-time and secure.

Emotion integration for emotion aware IoT services in Web of Objects, harmonize the better IoT services in every aspect of human activity[3].

The general architecture of IoT is shown in figure 2.

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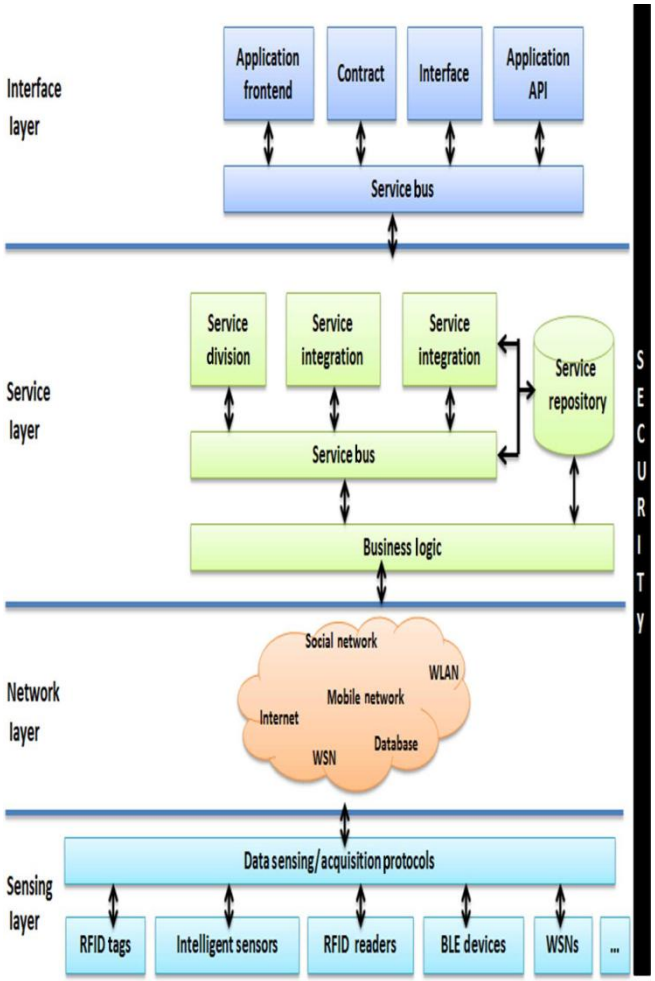

Figure 2. IoT Layers

B. *Emotion Recognition*

Facial expressions play a vital role in the efficient human-computer interaction. Human face reflects these emotions by facial expressions. These expressions can vary in intensity, meaning and the emotion behind it. Facial expression recognition systems need to analyze the facial actions regardless of culture, gender etc.

It has a vast number of applications such as Human-Computer Interaction, Security, Entertainment, Effective Computer Tutor, Intelligent Customer Services, Intelligent Home Robotics, Gaming and many more.

According to Mehrabian, 55 the facial expression of a speaker accounts for about 55 percent of the effect, 38 percent of the latter is conveyed by voice intonation and 7 percent by the spoken words[7]. Ekman has defined the six emotions as basic emotions. These are: Happiness, Sadness, Fear, Disgust, Surprise and Anger. Most of the research in the literature of expression recognition is focused on these basic universal facial expressions.

The general approach consists of three steps

- Face Acquisition
- Facial Data Extraction
- Facial Expression Recognition

These basic expressions are shown in figure 2.

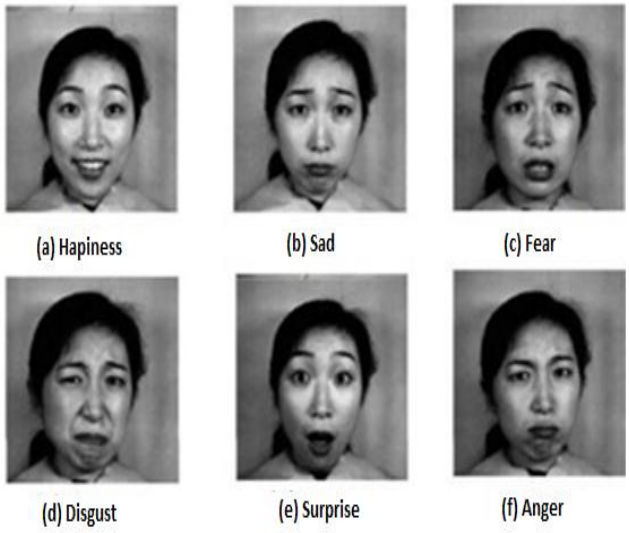

Figure 3. Basic Universal Facial Expressions from JAFFE Dataset

II. APPLICATIONS OF EMOTION RECOGNITION FOR IOT

Emotion Recognition has a vast number of applications for IoT to make it human-centric. Some of these are:

A. *Security*

The intentions of a person can be recognized by the facial expressions. The system should be able to detect a person's expressions and report to the security is the expressions are recognized harmful. And also, if the intentions of the person are harmful then the home gates can be locked with a notification to the members of the family. Security system, visual surveillance requires facial expression recognition system that works adequately on low-resolution images.

B. *Healthcare*

Sometimes due to non-availability of staff or a large number of patients it becomes difficult to keep an eye on every patient for every moment, Facial expressions can provide many benefits in the healthcare domain. For example, a person's mood/comfort can be inferred from the emotion recognized from the facial expression and the data can be sent regularly to the doctor or the guardians so that if any intense emotion is observed then some appropriate action is taken. Patient's feelings about the treatment can be observed using facial expressions.

C. *Indoor Comfort Monitoring*

The comfort of a person indoor can be analyzed by facial expressions. Different expressions can be classified as different emotions and can be used to control the temperature, volume or lightning in the indoor. The system should be able to learn the decisions and act accordingly in the future. For Indoor Comfort monitoring IoT can be used as shown in Figure 4.

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Figure 4. Indoor Monitoring

D. Marketing

Emotions are vital in purchasing decisions. Impact of ads and online shopping experience can be enhanced by analyzing the attention and engagement of the user. If the user is not happy with the ad/content then different ads or content can be displayed to the user. If the user is attentive and more engaged then the related relevant things can be displayed. The sales can be improved by taking the emotions into consideration.

E. Gaming

The levels of the game can be adjusted according to the expressions of the gamer. If any stress is seen on the face of the gamer then an easy level can be presented or a bonus can be given to proceed further. In case of neutral expressions, the game can be presented a bit complex to make the interest of the gamer. For Multiplayer Online Games(MOG), emotion recognition is very important to keep the interest of the gamer[4]. The expressions have to be recogized in real time and the system should be able to respond in the real time.

F. Driver Monitoring

The symptoms such as drowsiness, fatigue, or even inebriation can be analyzed by facial expressions. If the driver is detected tired then an alarm can be set up to make him alert or an alert can be sent to the nearby cars to slow down.

G. Entertainment:

In entertainment, the multimedia content can be displayed by analyzing the human's mood/behavior. The videos or songs can be changed according to the expressions of the user.

H. E-Learning

For an online class, the presentation style of the tutor can be adjusted according to the state of the learner. The state of the learner can be recognized by the expressions. The tutoring system can be made interactive and effective according to the stress level of the student. It becomes very easy for the computer tutor to analyze feedback from students through the expressions of students. A computer tutor can present an easy question for the student if it finds the student tensed/confused [6].

I. Human-Computer Interaction

Social robots are the near future of the Artificial Intelligence from doing household work to entertainment. These robots should be able to recognize the emotion of the person and respond accordingly. Face to face communication in real time is the key to efficient communication [5].

J. Smart Fitting Room

Smart virtual trial room lets the user virtually wear a dress and see if it fits. Based on the expressions of the user, the dress can be removed from the recommendation or similar dresses can be presented to the customer. The customer experience can be extremely delightful by not actually trying any dresses and consuming less time for seeing a lot of dresses.

III. FUTURE SCOPE

Although there have been many advancements in the field of IoT and Facial Expressions. Still, there is a lot more to achieve. The IoT is in the initial phase and there are many challenges such as Scalability, Security and Privacy, Fault Tolerance, Energy Efficiency, Software Complexity, Communication, Interoperability. These issues need to be addressed in the future to make the IoT with emotion embedded systems a success.

Real-time communication of the devices, analysis of huge amount of data generated from the devices and learning of the devices without human interference are still a challenge.

For facial expression recognition, most algorithms work on the frontal face view. To make the system more subtle, the system should be able to recognize expressions for the non frontal view, in abnormal lightning conditions, low resolution images. Also apart from the basic six expressions, there are many other emotions which can be single emotion or blended emotion. The emotions such as pain, love, hate, and mental states such as agreeing, disagreeing, lie, frustration, thinking etc. should also be focused as they have numerous application areas.

It is near future that alarm will wake you up with announcing all the important tasks for the day and will send signals to the coffee maker for brewing the coffee and to geyser for hot water. The devices will announce the name of guest with the mood. The music system will play music according to the mood of the user. By 2025, 1 trillion devices will be connected to the internet and will work in cooperation. It's a challenging task to analyze the huge amount of data generated by these machines.

IV. CONCLUSION

In this paper, various applications of Emotion Recognition to IoT are discussed which can make Artificial Intelligence a reality. Although a lot of advancement is made in the field of IoT still the enviroment where devices can learn on their own are in their infancy. There are many challenges such as security, real-time communication, big data handling to make

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the things work efficiently. These issues need to be addressed in the future.

ACKNOWLEDGMENT

We are thankful to University Grand Commission for providing Senior Research Fellowship for carrying out this research work.

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