

Research Article

Multi Modal Emotion Recognition and Sentimental Analysis for Next Generation Home Automation

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A B S T R A C T

Intelligent devices are the attraction of next generation systems where it does the work automatically without any supervision. Studies on Intelligent Systems shows various approaches in making systems intelligent and how their decision making capabilities are enhanced. All the existing systems involve some sort of human supervision in making decisions. Traditional Human-Machine interaction may not be possible in emergency situations or in real world busy situations. Hence it's time to think on Intelligent Systems capable of doing tasks without any supervision. Such systems can completely avoid human interventions or any form of instructions. My proposed research study is focusing on Intelligent Devices in a home environment that can assist in day to day activities of the residents in aware of situations. Such devices are capable of recognizing its environment through resident's voice, emotions, life style, routine, etc and can take decisions appropriately. Also it can provide personalized assistance to individual resident or guests. Hoping that such a system can reduce the workload of human beings and surely it will be a new direction of research in this field.

Keywords: Home Automation, Intelligent Systems, Sentimental Analysis, Emotion Recognition

Introduction

The term home automation has been around for a long time but the technology was not developed enough to make it a reality. Finally, around 1984 home automation or smart home became a reality and which is now common but still under evolution! We all know that the real world is running under a tight schedule which will be more tightened on a daily basis. Due to work pressure, environment problems and other personal emotions individuals are unable to hold things around the world within their hands. As we are moving towards the worst situation, we should have some smart intelligent systems that take our emotional values into consideration and help us to manage some stressful situations like a friend or mom without further supervision. Imagine that your too fatigue and coming to the home.

Unfortunately, nobody is there at your home. But when you enter kitchen, coffee vending machine makes coffee for you!!! How will you feel?! This is what going to happen in the nearest future with the scope of smart devices but not limited to!

Related Works

A home automation system has been going through several evolutions on a daily basis with the growing demands of human beings. Let's go through some of the previous works on home automation and sentiment analysis to know the evolution and real challenge faced in fulfilling increasing needs and wants of sentiment based home automation system. An early work on home automation based on SMS technology⁸ was a stepping stone to smart home technology. This work aims to design and implement a cost effective

but yet flexible, adaptable, and secure home automation system that consists two main components; a GSM interface which enables the communication between user and home automation system and a microcontroller that act as a bridge between GSM module, sensors, and actuators of home automation system. The automation system does its work through manual instructions given via SMS. The SMS-based system widely used to control telecommunication devices and electrical home appliances effectively. Though it has many advantages, it couldn't contribute to energy saving which is a growing need of the world. With the increasing demand for energy conservation,¹⁴ energy efficient home automation system is required which is capable of turning on or off devices only when needed. Additionally, controlling of HVAC (Heating, Ventilation, and Air Conditioning) system to save energy based on the presence of residents. Sometimes the presence of residents may also cause high consumption of energy. To tackle this situation, it has been proposed²¹ resident's behavior based home automation where the sensors monitor the motions of the residents inside the house, their habits, different actions, lifestyle etc and identify their behavior patterns. Such situation aware system contributes much more to human-machine interaction through perception from environment with respect to time or space. Continuous monitoring of surrounding elements results in periodical updation in user behavior patterns with every situation change.²⁹ But, an intention aware system can contribute much more to human-machine interaction over situation aware system, since it could reduce informational burden on humans without losing efficiency [30]. Also, miscommunication and uncertainty can be minimized with tracking of semantic and affective information associated with human actor's intentions. Experiment results show a considerable reduction in electricity consumption on the implementation of such a behavior based system. Another similar work¹⁴ in which a monitoring system collects resident's features and fed it into a recommender system. Based on identified features, recommender system suggests actions in smart home to lower energy usage without affecting the comfort level of residents. Another related work based on context aware technology proposed in [28] where a context aware comfort index is calculated to predict how user feels under particular environmental condition. Later, this index used to formulate energy saving optimization problem to minimize energy consumption.

Since the needs of users are endless, smart home revolution took new directions in the field such as voice recognition, health monitoring of residents etc! Home automation system starts to work with recognition of voice commands given by the user or house resident. Such a system able to control all lights and electrical appliances in a home

or office using voice commands.⁹ Another related work²⁶ which recognizes gestures of house resident and does actions. This system really helpful for elderly and disabled, especially who live alone. In order to provide a convenient and comfortable environment, it has been designed to recognize finger and hand gesture through the interface for physically handicapped people based on stereo cameras to achieve remote control and gesture recognition system. Some more improvements in the existing system made it capable enough to monitor the health of resident, especially old ones. This smart home technologies offer potential benefits for assisting clinicians through automatic health monitoring, report generation etc.^{16,17}

From old age itself, others opinions and suggestions have a significant influence in decision making process. Sentiment analysis and opinion mining are common in predicting the behavior or attitude of an individual towards a product or service in marketing. It may be positive, neutral or negative. According to which further decisions can be taken at higher level management. This can be extended to develop a home automation system.^{4,24} proposes a home automation system with social networks where user status like twitter tweets was collected and identified its polarity. Later the control signals send to a central hub where the appropriate actions take place. Say for an example, the user tweets "it's too hot outside" and the mood identified as 'the user is now outside of his home'; 'it is too hot'. This understanding makes air condition or fan to work before the user comes back to home. Bell et al.³ put forward a novel approach to explore micro-blogging in order to manage human-machine interaction. Also, an automated home promises very high entertainment values such as playing music, movies, indoor game suggestions etc. In recent years, the sentiment analysis has been explored by different services to recommend contents according to human emotions expressed through informal texts posted on social networking sites. However, sentiment analysis identifies metrics in terms of positive, negative and neutral polarity; it does not detect sentiment variations in accordance with user's profile.¹ Presents a music recommendation system based on sentiment metric, called enhanced Sentiment Metric (eSM). This eSM is used to find the intensity of sentiment in accordance with user's profile, based on which music recommended to the user.²⁵ suggests a document retrieval system that returns a number of documents based on the sentiments and topics given in the input query.⁷ Proposes a sentiment oriented information retrieval from documents based on the feelings within the narrative trends.

Text inputs are a major source of sentiment analysis and most of the algorithms work on textual information but, we cannot extract emotions by traditional sentiment analysis techniques. Hence concept level sentiment analysis is

required to overcome all the issues and difficulties faced during sentiment analysis of textual data as in⁵ where Concept Level Sentiment Analysis (CLSA) being performed. Input text processed through a well-defined set of activities such as micro text analysis, semantic parsing, subjectivity detection, anaphora resolution, sarcasm detection, topic spotting, aspect extraction and polarity detection. Similarly, other inputs like voice or video can also be used for sentiment analysis.²³ The voices of customer extracted from product review audio files are very useful for marketing.² suggests Voice of Customer analysis system that captures voice from audio files, stores it and analyzed to predict customer preferences. Automatic sentiment extraction from natural audio streams is a challenging research area. In,¹² the author proposed a Part of Speech tagging mechanism and Maximum Entropy Modeling to develop a text based sentiment detection model.¹³ Presented a similar approach to extract sentiment in YouTube videos. It's a truth that images are the most striking medium through which people can express their emotions on social networking sites. Social media users are using images or videos to express their opinions and share their experiences. Sentiment analysis of such large scale visual content can help better extract user sentiments. In,¹⁹ an image sentiment prediction framework is built with Convolutional Neural Networks (CNN). This framework is pre-trained to improve the efficiency of detection and results shows that CNN approach could perform better in image sentiment analysis than other similar networks. As we told earlier emotion recognition helps a lot in offering different services to its user.¹⁵ identified six facial expressions and developed a facial expression coding system that is able to detect emotion. Today's AI systems or expert systems are as efficient as humans, but it can't replace a human by machine because of a common sense knowledge element present in human intelligence. The facet of sentiment analysis can bring into next level by adding a commonsense knowledge in it which is made possible in senticnet4.⁶ As in,³⁰ human intentions can be used to perform concept level sentiment analysis. An integration of intention awareness and sentic computing may be extended for sense making in joint cognitive systems.²⁷ Such a system contributes better results in decision making intuitively.

From the above discussion, it's clear that the sentiment of a product or service can be derived from textual, audio or visual inputs. But still, we are looking for accuracy and efficiency. The unimodal system could not offer enough accuracy. A bimodal system combines one or more features such as audio or visual, visual or textual together to predict sentiment of a product.¹¹ proposed a bimodal system and showed that a bimodal system has more accuracy than any unimodal system. Many researchers came in fusing

different features to improve the efficiency and accuracy of sentiment analysis and emotion recognition. As research progresses, the bimodal system changed to a multimodal system where multiple features fused to recognize the sentiment from different aspects. A multimodal sentiment analysis performs analysis of emotions, attitude, and opinion from the audiovisual format. Some sentences in the textual reviews may derive deep emotions but do not contain any keyword to detect those emotions, so we can make use of audiovisual reviews in order to detect emotions from the facial expressions of the user. The author in²⁰ took audiovisual data as input, and then extracted emotions from video and audio in parallel. Finally, extracted information classified for polarity detection.¹⁰ proposed a multimodal sentiment analysis technique where single modal analysis performed individually on each type of inputs, later results combined to form multimodal. The results show that it is useful to find the sentiment of depressed persons.²² fused textual, audio, and visual features together. This work also could not contribute well in predicting both emotion and sentiment analysis. Hence, a common framework for multimodal emotion recognition and multimodal sentiment analysis are required. Some recent works show that Convolutional Neural Networks¹⁹ are useful to fetch features from video data and Recurrent Neural Networks can model time sequence dependencies among images and can be used to capture spatial and temporal patterns from the video sequence. But, CNN and RNN alone can't provide good classifications. Multiple Kernel Learning is a feature selection method where features organized into groups and each group has a kernel function. MKL could combine data from different modalities effectively. In¹⁸ proposed Convolutional Recurrent Multiple Kernel Learning (CRMKL) model which combines sentiment features from audio, video, and text with the fusion of CNN, RNN and MKL that results in increased speed up and accuracy. On comparing unimodal, bimodal and multimodal sentiment analysis and emotion recognition, there is a tremendous gain in accuracy of 79% in unimodal to 96% in multimodal sentiment analysis. Similarly, in the case of emotion recognition, there is a gain in accuracy of 60% in unimodal to 79% in multimodal emotion recognition.¹⁸

Problem Definition

Home automation systems gaining more popularity in the busy real world than earlier. Definitely, it has many things to do!! Almost all houses in the next generation will be a smart home. Surely, it will be a basic need of every person because of growing demands, stressful life, unhealthy lifestyles etc. Most of the current smart home systems depend on environmental factors, behavioral aspects of user etc to offer appropriate services whereas emotional factors and common sense knowledge holds very less importance.

Since it offers a general framework, individuality could not be preserved. Few works suggested unimodal features for sentiment analysis and emotion recognition, but according to,¹⁸ such a system offers low accuracy and efficiency and it is advisable to go for multimodal sentiment analysis and emotion recognition to achieve better efficiency and accuracy. It's clear; a personalized smart home system which preserves individuality among groups is highly required to satisfy the needs and wants of future generations. This opens doors to research challenges like How to design and implement a smart home that preserves the individuality of user with a full focus on emotional factors and common sense knowledge? How multimodal sentimental analysis and emotion recognition help in preserving user choices? How to make home appliances to think rationally in accordance with user's mood change? What is the role of sentiment analysis in controlling and managing future generations? etc.

The main objectives of this study are:

- To design and implement a home automation system which is purely based on the emotional factors of the user rather than environmental factors, general behavior etc. but that also a concern.
- To develop a new framework to predict user sentiment, which focus on multiple parameters for prediction and interpretation rather than focusing on one or two common parameters.
- To derive the correlation among different parameters determining human behavior.
- To perform a comparison among existing automation systems and future models.
- To demonstrate how the inclusion of common sense knowledge or human intentions affects decision making.
- To evaluate the scope of multimodal sentiment analysis and multimodal emotion recognition for future generation.
- To preserve and respect the individuality of users in every aspect.
- To derive interdisciplinary applications with a prime focus on emotions or common sense.

Proposed Methodology

The system may be designed as a well trained neural network capable of processing each and every feature of human beings including their common sense knowledge from textual, audio and video inputs captured through sensors placed at appropriate locations. It takes actions according to the polarity and emotion recognized that may be controlling an HVAC system, playing music or even sending an email. The design of entire work can be organized as follows.

The proposed system can offer following benefits or applications but not limited to:

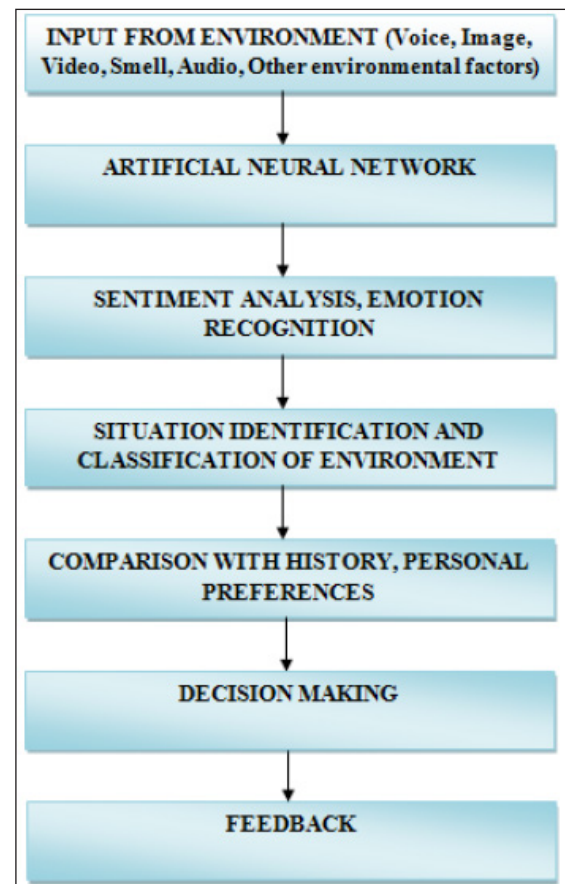


Figure 1. Work flow Diagram of Proposed System

- This study may be a stepping stone to identifying the potential problems with existing systems and may open door to new research challenges or opportunities in the field of sentiment analysis and home automation.
- Results in introducing a new framework to evaluate and predict human behavior and for improved human-computer interaction.
- Living standards of the employed population may be improved as they feel happy, relaxed, satisfied and motivated and hence they can perform better at their workplaces.
- Old age peoples and independent livings may get benefited.
- A fully automated home can offer entertainment, energy management, increased safety and security, access control, interface to the external world, surveillance and much more!
- This application can be extended to other areas like Factory automation, Automatic information retrieval from large databases, Blind navigation system, and Performance analysis of employees (Smart Office).
- Simply, everything can be made smart.

Conclusion

Devices with intelligence and autonomous features can do better when compared with traditional smart devices as it won't wait for instructions or any form of human intervention. Since the system got the provision to take decisions and can act accordingly there is no time loss, no need to train the system. Everyone can enjoy wide range of benefits irrespective of age and sex. Enhanced version and implementation of the same can open doors to challenging applications in the field of research, education, health, space research etc.

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