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SMART SPACES: A COGNITIVE APPROACH

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ABSTRACT

Advances in technology enable users to increase their standards of living to make their life easier and comfortable. Smart spaces aim to enhance the intelligence level of the living environment and improve the quality of human life. Users are expecting spaces such as homes, buildings, campuses etc. to work for themselves. Cognitive Smart Spaces autonomously increase energy efficiency along with sensing, understanding and even predicting the needs of occupants. They are also capable of recognizing users and situations they are in and the spaces should react accordingly, e.g., by providing certain services or changes in the surrounding environment such as temperature, light illumination, HVAC systems etc. Therefore, cognitive smart space developments are gradually coming to different application domains, each with corresponding specific characteristics. The paper discusses different technologies and methodologies for development of systems for various cognitive smart spaces. This paper also presents case studies in the context of Cognitive Smart Spaces. Also, it gives a brief introduction about the various hardware and software components for the development of Cognitive Smart Spaces.

Keywords: *Cognitive Smart Spaces, Sensors, Data Acquisition Systems.*

Introduction

Smart Spaces have become one of the most interesting areas of research in the past few years. Smart Spaces are also known as connected spaces. These are the physical locations equipped with different types of sensors to give users/ occupant's better information about the condition and accordingly predetermined necessary actions are taken. Smart Spaces can range from a smart home, smart campus, smart corridors etc. to a vehicle that constantly reports its location, performance along with the maintenance needs [1]. Smart spaces use sensors and microprocessors/ microcontrollers-based systems along with actuators to collect data and information in order to provide useful services, such as monitoring the daily activities, safety, health and security of the occupants. Smart spaces are not likely meant for interconnection of different devices/ things in our surroundings but an environment where the devices respond to occupant's behaviour and the needs. Here, the word cognitive implies the human decision making capability using necessary algorithms. Human voice-tones, facial expressions, vocal expressions can be considered for building cognitive computing-based AI solutions. Efficient algorithms, applications, and big data can benefit cognitive computing. Human emotions and environment data both help training and building the cognitive smart space applications [6]. Cognitive space senses the events derived from user interaction and system trigger is able to provide the stimuli [8].

Smart spaces consist of a large number of devices as per the user needs which are interacting with each other along with the occupants.

Smart space development is based on designing of the system where different types of sensors, processors etc. that is different types of technologies and methodologies have to be used. As the systems are customized systems, while designing the smart spaces, we should consider the technology centric to user centric approach as different users have different approaches or expectations towards the different/ various spaces to achieve convenience and safety along with the security.

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Smart spaces can be developed for different systems as shown in fig.(1)[4].

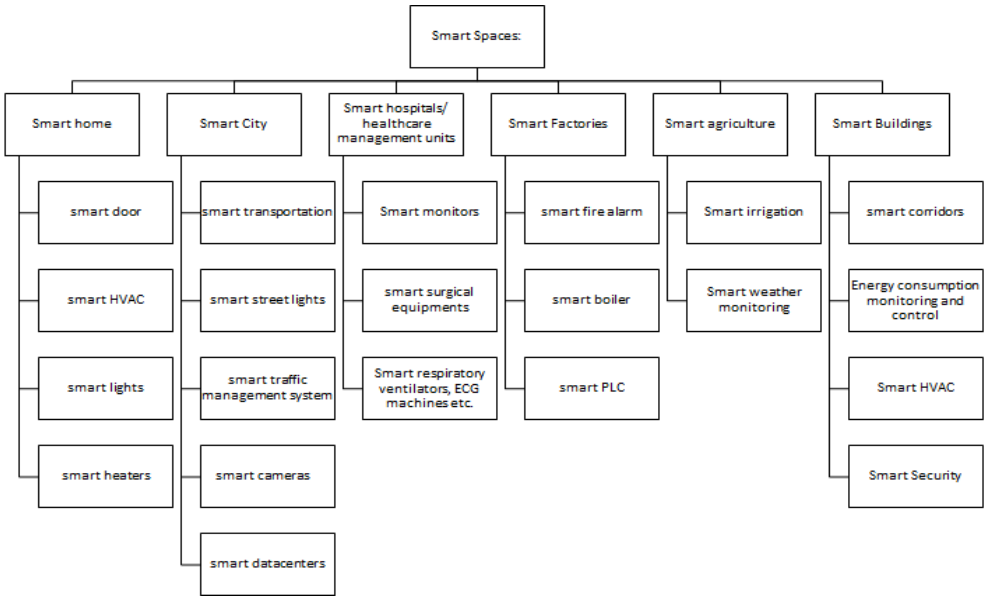


Fig. 1: Various Systems to be implemented in a particular Smart Space: Applications

Various Cognitive Smart Systems: Case Studies

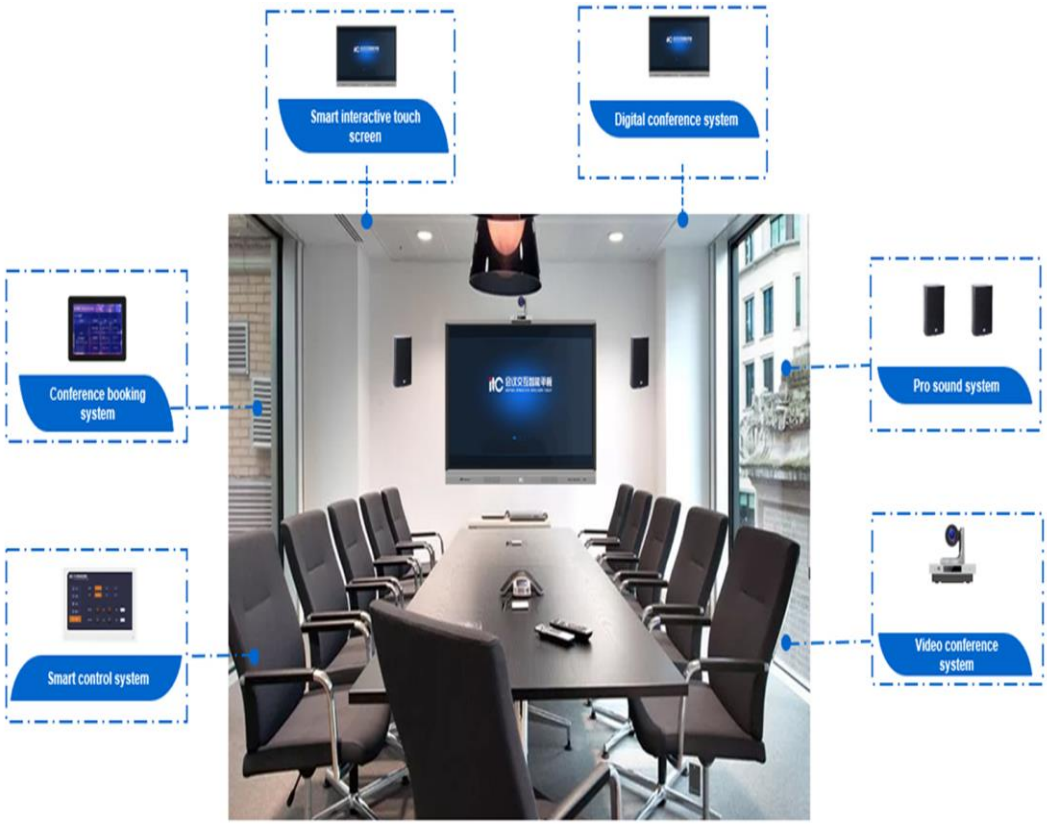
As mentioned in fig. (1), various cognitive smart systems can be developed. Some of the case studies like smart home, smart city, and smart conference room are shown in the fig. (2), (3) and (4).

https://economictimes.indiatimes.com/tech/software/home-smart-home-the-indias-booming-home-automation-market/articleshow/74630996.cms?from=mdr

Fig. 2: Cognitive Smart Home

https://thepsychometricworld.com/5-technological-trends-that-is-changing-the-workplace/

Fig. 3: Cognitive Smart City



https://www.itctech.com.cn/solu/index/art/3700.html

Fig. 4: Cognitive Smart Conference Room

Block Diagram

Block diagram for designing the cognitive smart spaces is shown in fig. (5). To design the cognitive smart spaces the important blocks are sensors, data acquisition systems, ADC/DAC, SBCs, user interface, actuators and also cloud and internet platform for communication is required.

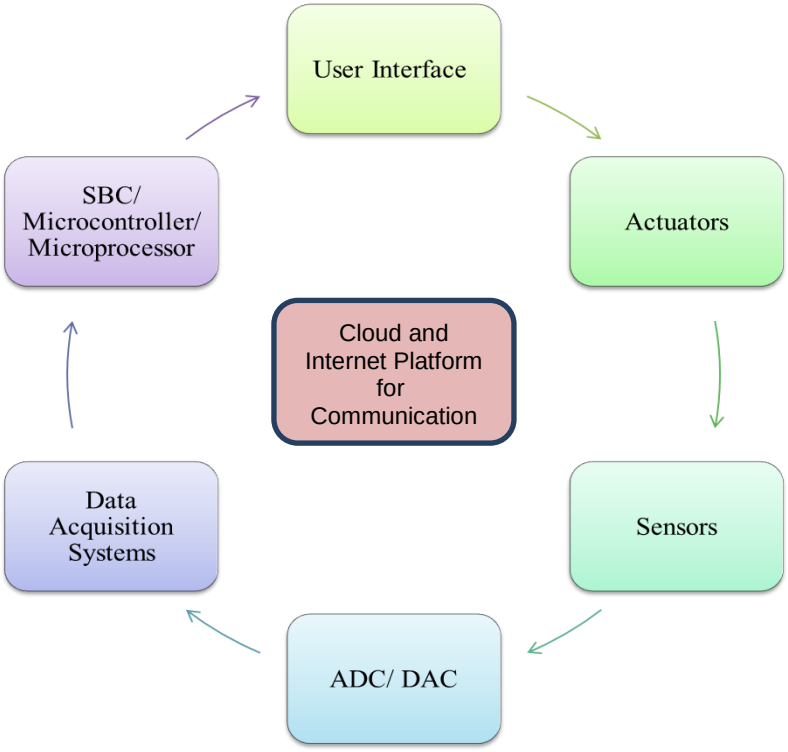


Fig. 5: Block diagram of Cognitive Smart Spaces

Sensors are the primary elements to be chosen to design any cognitive smart space. Sensors sense the physical parameter and convert it into an electrical parameter. While selecting the sensors, user requirements and specifications of sensors should be studied properly. A data acquisition system performs the tasks like conversion of data, storage of data, transmission of data and processing of data. Single Board Computers are basically used to write software so the system has to work as per the user's expectations. Microcontrollers/ microprocessors or SBCs like Raspberry Pi, Arduino etc. can be used as per the system requirements. ADC/ DAC are used for interconversion of analog data into digital and vice versa. Actuators are the devices which convert the given electrical signal into a motion. User interface: Also known as GUI (Graphical User Interface). It is used to set parameters or switch ON/ OFF any system. In short, Sensing, acting and computing are the important stages to be considered [3].

For interaction between the user and the devices, internet and cloud platforms are required.

Methodologies and Techniques to be Used

While considering methodologies or designing of cognitive smart spaces, the very first thing is the selection of sensors. As the systems are customized systems, different types of sensors depending on the user's requirement have to be selected. While selecting the sensors, it is very much necessary to study all the characteristics or specifications of the sensors. Depending on the output of the sensors, study of data acquisition techniques and identification of the simulation tools is required for the development and analysis of the Cognitive Smart Spaces. Next it is required to study the floor plan or the space under development and define the locations for the object instalment/ emplacement. After sensors selection and study of floor plan; sensors and other devices such as actuators, cameras etc. are needed to be installed at specific locations.

While installing the sensors/ the things, care should be taken about the privacy, security and convenience of the user. In order to make predictions or decisions, designing/ development of Artificial Intelligence/ Machine Learning algorithms for the required adaptation in the parameters under control is the necessary step. Design different modules like Processing module, Sensor module, Transceiver module, Power module etc. for the development of various Cognitive Smart Spaces so as to sense the parameters under consideration, make the appropriate decisions and perform the proper action. Depending on features of Cognitive Smart Spaces design its framework. Develop the software for the Cognitive Smart spaces using the different tools like MATLAB, LABVIEW etc.

Various hardware platforms like microntrollers/ microprocessors or SBCs such as Raspberry Pi, Arduino UNO etc. can be used to design the system and software components for the Cognitive Smart Spaces. The platform required is the internet. Systems will be IoT based systems which use artificial intelligence along with machine learning algorithms to satisfy the user needs while designing the cognitive smart spaces. To store the huge data which is generated from sensors has to be stored in the cloud. So that user can do computations as well as user can use the data later as per requirements. Very important step in designing is to study and analyse the user experience with the system and accordingly modify the system as per the user requirements so as to give user satisfaction along with the convenience, security and privacy [2].

Challenges Faced while Designing the Systems

While designing the cognitive smart spaces designer face many technical as well as non technical challenges. Technical challenges are like addition or removal of devices, reconfiguring the smart spaces, handling multiple users at the same time, multiplatform, multi language environment, data acquisition, privacy of users/ occupants, adaptation with the changing environmental parameters etc.[7]. Non technical challenges are user's profile, user's knowledge, user device interaction etc. By studying all these parameters in detail, designer needs to work on the problems and come up with the best possible solution [5]. Privacy of the users/ occupants is the concern while locating the sensors as no camera or no video recordings are used to maintain the privacy of the volunteers/ users. [9] [10].

Conclusion

Cognitive smart spaces are the spaces designed to make the occupants life easier, comfortable and also to improve their standards of living. As the systems are customized systems, designing algorithms may vary person to person. Privacy and security are the major concerns to be considered. The system should be able to adapt itself to the changing environment. Designing of the systems is the continuous process because user's feedback plays a very important role and depending on users feedback changes in designing or System modification are required to be done.

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