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A Study on the Contributing Technologies of Ambient Intelligence

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ABSTRACT: Ambient intelligence is an evolving area of computer science. Using AmI we integrate intelligence in our environment which in turn makes it more interactive. Intelligence here means that the systems can sense the environment, recognize the actions of the user and respond to the user. The systems act according to the activities performed by the user. In this paper, we focus on the contributing technologies of AmI like sensing, acting, reasoning, human computer interaction and privacy are discussed in this paper.

KEYWORDS: Ambient Intelligence, acting, sensing, reasoning, human computer interaction.

I. INTRODUCTION

Ambient intelligence is an evolving area of computer science. Using AmI we can integrate intelligence in our environment which in turn makes it more interactive. Intelligence refers to the systems that can sense the environment, recognize and respond to the environment. The systems act according to the activities performed by the user. It is transparent. Transparent refers to the systems which are networked together will decrease in size such that only the user interface will be present [1].

All the information and the intelligence that is given to the environment are hidden in a network. Now, as the devices become smaller and smaller they will all get integrated and will be completely hidden i.e., it will disappear and only the user interface will be present for the users to use [2].

It introduces intelligence in our environment. It helps the people in doing their everyday activities and tasks in an easy way. This Ubiquitous computing and Pervasive computing introduces the concept of intelligence in AmI. Ubiquitous computing is one where the technology will be found everywhere .For e.g.: implementing processors in our everyday objects and so on. Pervasive computing is the one where these systems will be widely used.

In AmI, many network devices will be integrated together, the environment will recognize the user and the situation, and it will respond to the user and will help the user. It can also judge what the users wish for and adapt according to the situation.

It depends on three concepts:

- Ubiquitous computing: Here, we implement microprocessors in the objects that we use in our daily life (e.g.: laptops etc.). The people who work in the environment will not be aware of the integrated component that provides intelligence to the environment [3].
- Ubiquitous Communication: Here, the components that are integrated will communicate or interact with the users and also amongst themselves.
- Intelligent User Interface: The users can control the intelligence in their environment and interact with it. This interaction can be in verbal or non-verbal form like voice etc [4].

When computers were first invented, not many were open to the idea of using a computer. People did not understand how to use it. Multiple people were required to operate a single computer. Due to a lot of research and development, there came a point where one person was able to operate a single computer. Due to further development in technologies, we are at a point where one person or user can use multiple computers at a time. These systems need not be particularly computers; they can be any device like a mobile phone, laptop, washing machine etc. Due to this development in technology, AmI emerged where in, the system can identify the user, recognize the actions and respond to the user [5].

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II. CONTRIBUTING TECHNOLOGIES

AmI contributes a lot to machine learning, robotics and so on. The technologies that contribute to AmI are divided into five groups. They are as follows: [5]
The five groups are sensing, reasoning, acting, human computer interaction, privacy and security challenges.

A. Sensing:

In AmI, the intelligence is given to the environment. Environment in which it works has to be sensed in order to respond to it. Therefore sensors are used. Sensors are transducers [6].A transducer is a device which takes input in one form of energy and produces the output in another form [7]. In ambient environment, the sensors are objects which are used to detect the changes in the environment and produce an output according to the input.
If sensors are not used, then we cannot physically implement the intelligence in the environment. Therefore we will just have the theoretical concept and we cannot implement it physically in the real world [5]. Since sensors are very small in size, they can be used in any component.

- Audio Visual Sensors: It is made up of two systems, the audio system and video system. The audio system is used for speech recognition etc. It is used to detect and identify the speech and even find the position of the source. It can even detect the audio which is in non- speech form like laughter etc. We can combine both the audio and the video sensors in order to perform some tasks.
- Passive Infrared sensors (PIR): These sensors will detect the infrared radiations that are emitted from objects. These radiations are not visible to the human eye since they lie in the infrared wavelengths. The word passive in the term means that these sensors will not emit any radiation but instead are used for detecting radiations emitted from other objects. These sensors are usually used to detect the motion of objects [8].

- Radio Frequency Identification: This is being used in AmI in recent times since it can identify how close the object is i.e.; its proximity and also identify it. With the correct technology, it can be used in everyday objects. The RFI tags can also be injected in animals, humans, etc.
- Multimodal wearable's: Due to advancement in technology, we can integrate many sensors in one component and use it. For example, in recent times, all the mobile phones have GPS using which its exact location can be found [9].

AmI can either use a compact model or dispersed model. In compact model, the data is sent to the server and analysed. In dispersed model, each sensor will have some computational power; therefore they can locally process the data before sending it to the other nodes in the sensor network.
Even if the sensors are very useful, they still have disadvantages. The data that is generated by a sensor is very difficult to analyze. In case the sensors don't work properly, it can miss some values which might lead to some technical difficulties [5].

B. Reasoning:

The algorithms used in AmI and the real world are connected using sensors. In order to makes these algorithms useful, a lot of reasoning has to take place. The different types of reasoning are discussed below.

- Modeling: The normal computer programs and the programs written for AmI are different. They differ in the way in which they respond and model the behavior of the user. These models help in detecting or finding changes. It depends on how the data is used to create, use and indentify type of algorithm used. Generally, data for these models are taken from sensors since the data that is received from low level sensors are easy to collect and process. But the problem arises when there is a large amount of data.A simple motion and lighting information generates up to 10,360 events per day. This becomes even more challenging with audio or visual data [5].
- Activity Prediction and recognition*:* Using the reasoning algorithms we can actually predict and recognize the activities that take place in ambient or smart environments. In most of these applications, sensors are used. These sensors will sense, determine and in turn make it convenient and better for people to use the environment.The predictions can vary from finding a location to predicting what the user requires and so on. These techniques fall under unsupervised learning approaches. Whereas supervised learning approaches can be used when the data or information about the environment is already available. Using this data, the activities can be modeled and recognized. The data can be collected from accelerometers and so on [10]. Several activity recognition machines or applications can be developed using Smart phones. It has some advantages like portability, no extra equipment requirement etc. This is quite different from other applications where in sensors or other components are used for

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activity recognition purpose. Even if it is possible to use several sensors and increase the performance of the algorithm, it is still very difficult to judge how the user will use it and the drawback is the lack of resources [11].

- Decision making: Even though AmI has been kept improving from scratch, it is still very difficult to implement it. It still has a slight percentage of rarity in implementation. There are many applications where in automated decision making techniques have been implemented [5].Some researchers have put forward the idea of CAI (Computer assisted instruction). Here the computer is the instructor or the tutor. It will instruct and assist the student in solving a problem. For a particular class of problem, it will have some ideas where the probability of making mistakes is more. If it finds a student making one of those mistakes, it decides what type of mistake the student is making and provides assistance to the student to solve the problem. This assistance can vary from one student to another based on the mistake each student makes.One more example is "Sad Sam Program". This program can work only with limited number of inputs. It can identify different facts from a conversation. If there are two sentences as follows:"Jim is John's brother" and "Mary is Jim's mother" then Sad Sam is smart enough to identify that "Mary is John's mother" [11].
- Spatial and Temporal Reasoning*:* In AmI there must be references that tell when and where some meaningful events have taken place. Therefore, the system must know where the users are at a particular period of time. Only then, there can be clues on what the user is doing and what is the response of the system [5].
  Space and time will structure all our activities with the external world. But when compared to time, space is more complex since space is multi-dimensional. It is very difficult to reduce all the spatial knowledge into small number of concepts in a wide fashion. Therefore it has clearly become an important branch in AmI. Areas like robotics, natural language understanding etc have contributed a lot to this field. Spatial representation and reasoning has some numeric algorithms and describes them based on the representation of space [12].

Time also is one of the important areas in AmI. It has an important part in all the applications. This ranges from the logic of a particular application to knowledge based systems. Using sensors a lot of data can be collected and this data contains the information about the spatial and temporal dimensions of the system and the surroundings.

Spatio –temporal outlier (STO) is an instance whose non spatial attribute is different from Spatio -temporal environment. Forest fires, earthquakes are all examples of STO's. In order to understand them properly, they must be detected first. There are outlier algorithms that can be used in spatio temporal environment. When they are used, it must be kept in mind that STO's are local to the STN (Spatio-temporal neighbor). These STN's occur due to spatio-temporal correlation [13].

Let us consider the example of a smart home. Here the sensors are attached to the appliances and these appliances help the users in their daily life activities. The system will use the data from sensors to find when (temporal) and where (spatial) a meaningful event has occurred. Here the event can happen every day (cooking), once a week (cleaning the car), or once a year (birthdays, anniversaries) and so on. In case birthday is being celebrated everyday then AmI has to detect that something is not right. Temporal reasoning has to work even better, since it is used to find dangerous events like microwave oven left unattended for a long time [5].

C. Acting:

In ambient intelligent environment, the systems can sense and act. Here act means to perform some actions. AmI has evolved from a place where it was difficult to give instructions to a robot to a place where the robot can have conversational interaction with the user. Now robots are found in nursing homes where the requests are given to the robot. Example of one such request is "Get the medicines to the counter". These robots can also interact with the patients.

Now, robots can keep track and monitor their master and provide conversational stimulation. They are now able to showcase their emotions and are able to express them. In this way their interaction allows AmI to spread across the globe [5].

D. Human Computer Interaction:

If AmI has to be accepted socially, then it should be easy to use the system and it should be easy to live with the system. Therefore, the interfaces used must be human centric that are natural and are context aware.

- Context Awareness: In 21st century, there is a lot of development and research in machine to machine computing devices. These devices communicate with each other without the help of any human operator. For this interaction, these devices must be aware of their environment. This type of computing is called as context aware computing or sentient computing [5].Context aware means location and activity aware. Example of such a situation is a system that must be aware if the user is in the kitchen or hall. Whether the user is cooking or watching TV and so on. Here, devices monitor the current location and activity of the user and also about

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the surrounding environment. Research in this field has improved to an extent where the system can ascertain the content even with partial, incomplete, damaged or defective information. This is used in IBM's Context Sphere [18]. It uses sensors in order to monitor the environment and act accordingly. Using sensors, a model is made and the location aware appliances are then made. Examples of applications are as follows [14]: "Follow Me Phone" .The phone nearest to the recipient is made to ring. Location based games like Ingress [15].AT and T Laboratories Cambridge has an ultrasonic system called active bats where in which it was able to deliver location accuracy up to 3cm [16].

- Natural Interfaces: AmI is getting developed in such a way that the interaction between humans and technology will soon change. There is a shift from the conventional interaction to human centric and natural interfaces. Here the basic features of the user like context, behavior, emotion and so on are taken into account and then the user interfaces for the AmI applications are then developed.On one side the reduction in human centric interaction is encouraged. The system has to use its own intelligence in order to monitor and act accordingly based on the activities that are recorded. Human centric interaction is one of the areas of AmI that is very important and a lot of appliances are being introduced which incorporates this interaction. But, HCI does not allow AmI technologies from being ubiquitous [5]. Now technologies have been improved in such a way that motion detection and recognition of facial expression, gesture and emotions has been incorporated. Using them, it is easier to interact with the environment. One of the applications of natural interfaces is UCLA's Hyper Media Studio Project. Here the light and sound will get adapted based on the position and movement of the participant [17].One more application is the use of facial expression recognition in order to identify if the driver is sleepy and so on. Human verbal and non-verbal communication has become an important area of research in AmI. Using this type of communication, the system can interact with the user similar to a face to face interaction. A lot of research is going on eye movements, hand gestures, body postures and so on [5].

III. CONCLUSION

Ambient intelligence is an evolving area of computer science. Using AmI we integrate intelligence in our environment which in turn makes it more interactive. Intelligence here means that the systems can sense the environment, recognize the actions of the user and respond to the user. The systems act according to the activities performed by the user. In this paper, we focus on the contributing technologies of AmI like sensing, acting, reasoning, human computer interaction and privacy are discussed in this paper.

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