Ambient Intelligence

A Review of the Literature

Neil Soriano

University of California, Merced

Author Note

This paper was prepared for Writing 100, Section 1, taught by Professor Varnot.

Abstract

Ambient intelligence stems from artificial intelligence and it can be defined as technology interacting and responding to humans. For an ambient intelligent environment to exist, it must contain three types of system: sensing, reasoning and acting. The primary sensors used in ambient intelligence are audiovisual, passive infrared, and radio frequency identification technology. To simulate a more natural living environment, a fuzzy computing system is used. Using a fuzzy computing system can also make it possible for machines to understand culture by analyzing people's points of interests based on certain factors. Machines are also capable of generating and displaying creativity. Gaps in research and progression of ambient intelligence are still present due to the lack of trust and reliability these machines will possibly display.

Keywords: artificial intelligence, ambient intelligence, multiagent systems, fuzzy markup language, abstract protocol, artificial creativity, sensor networks, points of interest, machine ethics

Ambient Intelligence

A Review of the Literature

With the advances that technology has made over the last decade, what machines could do is different from what they can do now. The first IPhone had just released, voice control was barely making strides, but most importantly, the ASIMO (Advanced Step in Innovative Mobility) a humanoid robot created by Honda made its debut to CES, the (Consumer Electronics Show) in 2007. This invention was a huge milestone in the field of artificial intelligence as it was able to interact, listen and perform various tasks that involved moving carts and carrying objects.

ASIMO had different sensors spread throughout its body and a communication card that helped it recognize its current environment and interact with others. The sensors were strategically placed so that the robot could receive objects and even coordinate its motion with people. The force sensors in ASIMO's hands gave it the ability of handling a cart by itself, even when the cart was bothered, by modifying the forces applied in each hand. ASIMO's last capability was running up to a speed of 4 mph, whether that would be straight or in a circular pattern.

Honda's goal for the continuous development of the ASIMO is to one-day produce "a robot capable of assisting those who lack full mobility and of working environments in environments dangerous for humans" (Honda). In the field of artificial intelligence, the area that focuses on machine safely responding and sensing humans. As scientist's research more on improving and perfecting ambient intelligence, the use of capable machines in society will grow and try to make human's lives easier.

The specific area of focus in artificial intelligence, ambient intelligence, is venturing its way towards easing the lives of people through the interactions of technology and humans. Machines with ambient intelligence specialize in being quick in reactive and adapting to people's entities. Researchers and advocators of ambient intelligence hope that machines containing this technology will one day be able to recognize people's actions based on their emotions and preferences and accommodate towards their needs.

With studies focusing on ambient intelligent environments, sensor networks, fuzzy computing, culture recognition, and their creativity, the likelihood of artificial intelligence playing a more integral part in our society remains as a possibility. However, the potential areas that researchers plan to improve and focus on are still doubted by ethics and people's morals. Concerns include the moral and ethical cognition of machines, because in the end, the main priority is to protect humans from any dangerous decisions a machine may possibly make.

Ambient Intelligent Environment

For a machine to understand and successfully recognize patterns, the components of an ambient intelligent environment needed to supply the environment with intelligence must be implemented. These types of systems include sensing, reasoning and acting. Sensing can be divided into two areas of focus: "monitoring of the user and his/her

activities and monitoring of the environment itself" (Azitiria, Izaguirre & Augusto, 2010).

With the use of motion sensors, monitoring the user and what he/she does is important to track and identify them. As for the environment, sensors help gather data based on the temperature, amount of light and humidity of the environment, helping the machine study the user more.

Next, in the reasoning part of the system, the gathering of intelligence according to the environment. "Once the behaviors of the users have been learned and the activities the user is doing have been recognized, it is the moment of making decisions to act proactively" (Azitiria et al., 2010). Spatial and temporal reasoning must also be accounted for when the user's behaviors and biases are being studied. Spatial reasoning is when the machine can think of objects in three dimensions. Temporal reasoning allows the machine to reason using symbolism and by following a set of rules in respect to the time. This allows the machine to solve multi-step problems by itself.

Finally, the acting system is when the decision is being made by the machine, "some conditions need adjustment or human interaction is needed" (Azitiria et al., 2010). Examples of elements used for acting to help people in various ways include actuators, multimodal interfaces and robots.

Sensor Networks

Sensor networks in an ambient intelligent environment are crucial in answering the six principle questions: who, what, where, when, why and how. Sensor networks answer these questions by tracking and identifying persons and pets . . .; Providing a time frame for location and object associations to determine context . . .; Recognizing activities, interactions, spatio-temporal relations, but also linguistic and non-linguistic messages, signals, and signs . . .; Association of actions with action semantics, scripts and plans, identification of task and behavior patterns . . .; Tracing the information flow through multiple modalities, recognizing expressions, movements, gestures" (Pauwels, Salah, & Tavernard, 2007).

Sensor networks are useful for analyzing human behavior, once all the information needed is collected by the system. However, there are three important types of sensors used most commonly in ambient intelligence: audiovisual sensors, passive infrared sensors and radio-frequency identification (RFID).

Researchers use audiovisual observations to implement dependable communication skills with people into ambient intelligence. Some components used in the visual area of the sensor are tracking people and objects, recognizing people's facial expressions and body posture, and sensing where people's attention is being directed to. As for the audio portion of the sensor, besides the use for voice identification and recognition, non-speech vocalizations in respect to the activity and emotions being displayed, can be analyzed to determine a more general class of sound. For example, the ShotSpotter system uses "connected roof-mounted microphones to detect gunshots and triangulate the location of origin. The

system can even direct cameras to try and record the scene" (Pauwels et al., 2007).

Another sensor used in ambient intelligence are passive infrared sensors. These sensors record the spectral signatures given off by objects like humans, animals and vehicles, and use those signatures to detects the object's motions; they even help classify objects according to these signatures. If devices containing passive infrared sensors were surrounded in building that set on fire, "it becomes possible to detect fire and smoke, but also to learn movement patterns of the inhabitants, and novel correlations" (Pauwels et al., 2007).

The last sensor used mainly in ambient intelligence is RFID technology, which is capable of sensing and identifying an object. What's great about RFID tags is that they are small, require low power usage and are versatile. Placing these tags strategically allows the system to collect data from different tags and identify the main agents in the ambient intelligent situation. It is even possible to detect activity patterns with the right technology interacting with each other. Pauwels et al. (2007) mentioned an invention called the iBracelet, which contained a short-range RFID reader that register all the objects the user touches. However, these objects must have an RFID tag attached to it for the reader to register the object. RFID sensors tagged on the user "is also very useful for collecting ground truth data for face, gesture, body posture and speech recognition applications, which usually incorporate statistical models that require large amounts of data for robust operation" (Pauwels et al., 2007).

Fuzzy Computing

Different processes and techniques are used depending on the purpose that artificial intelligence will serve. In an ambient intelligent environment, a fuzzy computing system is ideal to make interacting with the living environment feel more natural. It also helps the devices within the system sense, adapt and act upon the situation according to the user's preferences and needs. The fuzzy computing system is defined into several categories named Design, Runtime, Service Retrieval and Fuzzy Controlled.

In the Design subsystem, the technology of fuzzy markup language makes it possible for the ambient intelligent environment to be projected in a clear and human specific way. The Runtime subsystem computes the agents defined by the Design subsystem. In the Service Retrieval subsystem, an algorithm selects the most suitable services for the user. The Fuzzy Controlled subsystem defines the services that the Service Retrieval subsystem selected. These subsystems can communicate to each other smoothly and efficiently using the Internet.

In ambient intelligent environments, "the possibility of dealing with a considerable number of heterogeneous control hardware is very high so to constitute real impediment for a flexible and efficient control strategy" (Acampora & Loia, 2008). A fuzzy control makes it capable for the machine to identify the controls using sentences, specifically IF-THEN statements instead of equations. The capabilities that fuzzy markup language have allow the machine to understand

customized tags, which makes it easier to communicate data to applications, other devices and organizations.

The diverse devices that act upon the ambient intelligent environments can cause all sorts of problems like using the wrong operations or protocol to communicate with. By using an ambient intelligence abstract protocol, these problems could be evaded since the set of usable operations for the scenario would be displayed on the interface. Abstract protocols use device drivers that act as the interface between the abstract protocol and the real protocol. The main focus of an ambient intelligence abstract protocol "is to realize a collection of objects having the same interface and implementing the different protocols used in" an ambient intelligence context. This makes it easier for the machine to organize its protocols and recall it to one location, which makes it faster and more efficient for the machine to execute an operation.

Culture Recognition

With the help of a fuzzy computing system, culture can be assessed and understood with the addition of some fields and agents. The point of interests is the driving force in the application of culture to an ambient intelligent system. These set of points of interest include an identifier, latitude, longitude, radius, keywords and time. The identifier identifies the point of interest; the radius uses longitude and latitude to recognize when a user is in the circle for a specific point of interest; the keywords list the point of interest's traits and help distinguish possible similarities and differences between other point of interests; time is the average amount of time recommended by the ambient intelligent system.

In the example Constantini, Mostarda, Tocchio and Tsintza (2008) used, a DALICA multiagent system was used to demonstrate how culture could be recognized using points of interests and its components. First, the user creates a user profile with basic data about themselves before visiting the Villa Adriana area at the University of L'Aquila. Once the visit commences, the system creates a user profile agent that it continuously updated and replaced depending on the decisions the user makes.

When deducing visitor interests, there are six indictors that gauge the user's possible interests. The first indictor, time, represents the amount of time the user spends at a location, which uses the radius of a specific point of interest to help determine its position. The second indictor is the amount of times a point of interest is visited, distinguishing the most visited as deduced interests.

The third indictor is used if the user chooses a route proposed by the system, analyzing the point of interests found in the given route. The fourth indictor uses a similarity measure to categorize similar points of interests that the user is interested in. The fifth indictor allows the system to ask questions about points of interest within the user's area to gather intel. The sixth indictor uses data that the user answers with to measure their cultural level.

To polish up the user's profile, "the second deduction phase repeats the steps of the first phase and compares the results to those of the first phase. This process selects

the most frequent interests that appear in both phases" (Constantini et al., 2008). The system is intelligent for running another trial to ensure the user that their results are real and not a fluke.

The agent then sends this list to the user for confirmation and makes sure that the user is receiving the best results according to their decisions. "Moreover, the agent communicates them to a central system that manages the visitor's information to propose (through the agent) information and POIs closer to the user's desires and expectations" (Constantini et al., 2008). The system does this to further decipher the results and to make sure that the user is receiving the best results possible for visitors to truly enjoy the Villa Adriana area in respect to their interests.

Creativity

Creativity in artificial intelligence was studied to understand creativity better as a whole. What can be found creative to humans may be interpreted differently by artificial societies, due to the different norms that exist within each domain. To make a computational model for artificial creativity, certain requirements must be met. The model contains a society of agents situated in a cultural environment. There is no agent that can direct the behavior of all the other agents. There are no rules in the agents or environment that dictate global behavior. Agents interact with other agents to exchange artefacts and evaluations. Agents interact with the environment to access cultural symbols. Agents evaluate the creativity and artefacts of other agents (Saunders & Gero, 2001).

Many of these requirements connect with the same requirements that artificial life needs. Having no rules or agents are essential in displaying the personal behavior produced by the entities. To show how artificial creativity emerges, a simulation run would start "by specifying some initial social configuration of the agents within a simulate cultural environment" and from then on, creativity would depend "on the interactions between different agents and the interactions between the agents and their cultural environment" (Saunders & Gero, 2001). Researchers believe that artificial creativity can be used to run simulations using different starting conditions to see the different possibilities that could have emerged if certain products had moved forward with a different type of society. Simulations could also help analyze the effects that products have on the nurturing and spread of creative ideas.

Gaps in Research

Despite the extensive research and positive intentions that ambient intelligence has, the concern lies with the moral thinking of machines. Even the most expensive and high-tech machines need to be continuously updated and taken care of. If the machine were to malfunction and behave inappropriately or dangerously, how much trust can people really place on these artificial intelligent machines? The main concern with machine ethics is the consequences that the behavior of the machine may react towards other machines or entities. It widens the subject of ethics since humans now must consider for "not only human action with machines but the behavior of some machines, namely those

that are designed to provide advice or programmed to make autonomous decisions with little or no human supervision" (Gunkel, 2007). The ethical impact of machines has for the most part been under human supervision, but as technology progresses, so will machine intelligence, demanding less human supervision, raising the question on the amount of ethical behavior trust an individual will feel comfortable with.

With the main priority of protecting humans from any dangerous decisions a machine may possible make, "machine ethics is exclusively interested in articulating ethical guidelines and procedures for the way machines deal with and treat human beings" (Gunkel, 2007). Releasing machines to the public without any ethical limitations on it can be deemed dangerous for humans. As researchers continue to gather more research and find ways to place restraints on their machines to fit seamlessly within our society.

Ambient intelligence wouldn't be possible without the research and development that artificial intelligence has achieved. Once machines can respond and interact with humans successfully, interaction with technology will become more prominent and common in our society. More milestones like ASIMO are bound to occur over the next couple years. However, considering the detail and precision being implemented for ambient intelligence to occur at peak performance, reaching these milestones won't be easy. Getting these machines to be used in our society will also face several obstacles in terms of being approved and accepted. In the end, ambient intelligence solely has one goal: to make people's lives easier.

References

Acampora, G., & Loia, V. (2008). A proposal of ubiquitous fuzzy computing for Ambient Intelligence. *ScienceDirect, 178*(3), 631-646. doi:10.1016

Aztiria, A., Izaguirre, A., & Augusto, J. (2010). Learning patterns in ambient intelligence environments: a survey. *Artificial Intelligence Review, 34*(1), 35-51. doi:10.1007/s10462-010-9160-3

Costantini, S., Mostarda, L., Tocchio, A., & Tsintza, P. (2008). DALICA: Agent-based ambient intelligence for cultural-heritage scenarios. *IEEE Intelligent Systems*, *23*(2).

Honda's Newest ASIMO Humanoid Robot Sprints to its North American Debut at the Consumer Electronics Show. (n.d.). Retrieved April 11, 2017, from http://asimo.honda.com/news/hondas-newest-asimo-humanoid-robot-sprints-to-its-north-american-debut-at-the-consumer-electronics-show/newsarticle_0064/

Gunkel, D. J. (2007). Thinking otherwise: Ethics, technology and other subjects. *Ethics and Information Technology*, *9*(3), 165-177.

Pauwels, E. J., Salah, A. A., & Tavenard, R. (2007, October). Sensor networks for ambient intelligence. In *Multimedia Signal Processing, 2007. MMSP 2007. IEEE 9th Workshop on* (pp. 13-16). IEEE.

Saunders, R., & Gero, J. S. (2001). Artificial creativity: A synthetic approach to the study of creative behaviour. *Computational and Cognitive Models of Creative Design V, Key Centre of Design Computing and Cognition, University of Sydney, Sydney*, 113-139.