Smart City: Evaluation of Intelligent Agents

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***Abstract*—This article evaluates the current situation regarding the development of Intelligent Agents. First, it introduces and explains in detail all of the defining characteristics of an agent, and how each trait separates an AI from a normal software code. Then, this article examines what Intelligent agents must possess in order to be successful, and outline the main problems that it faces. Finally, a few real-life examples are given in order to demonstrate the goals and purposes of a few different types of agents.**

Keywords—artificial intelligence, big data, intelligent agents, robot, world model

I. Introduction

Establishment of smart cities is a pressing global need as the world's population grows steadily and our societies become rapidly more urbanized. In 1900, about 14% of people on earth lived in cities. However, by 2008 half the worldwide population lived in urban areas, and the rate continues to grow. Artificial Intelligence (AI) is a recently emerging research field that is inspired by the ways people use human intelligence to sense, learn, reason, and interact with the real world. By definition, artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially by computer systems. These man-like processes include learning by the acquisition of information and rules for using the information, reasoning using rules to reach approximate or definite conclusions, and self-correction by machine learning. So far particular AI applications include expert systems, speech recognition and machine vision. AI could play a key role in numerous applications within the context of a smart city, from improvements to traffic and parking management to the safe integration of autonomous ride-share vehicles. As an application example, AI has made a significant impact on the Smart Transportation systems, where key technologies have catalyzed the widespread adoption of AI with astonishing speed for the integration of smart city. Autonomous transportation will soon be taken for granted and, as most people's first experience with physically embodied AI systems, will strongly influence the public's perception of AI and the smart city.

In the last couple of years, we have witnessed a dramatic growth in the platforms, tools, and applications based on artificial intelligence. These technologies not only impacted computer software, internet industry, but also other fields such as image recognition, health care, legal, manufacturing, automobile and agriculture [1]. One of the AI applications is the intelligent agents (IA) that is an autonomous entity capable of observing and acting upon information from its environment to direct its activity towards preset goals. Applications of IA have great potential for novel contributions to the AI research fields. This article does not aim at a thorough survey of the literature and detailing progress in all different directions of IA study. Instead, it is intended to communicate a way of thinking for IA systems in which basic functional elements are defined and assembled into interactive systems with smart properties and behaviors [2].

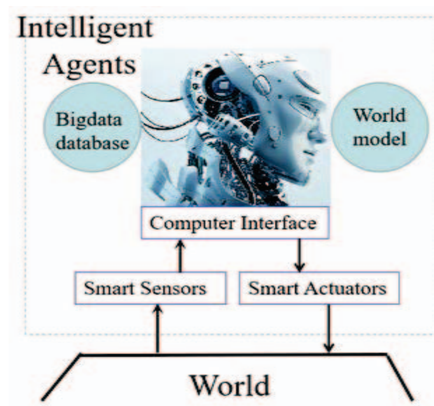

Fig. 1. Schematic diagram of the Intelligent Agent that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.

II. Intelligent Agents

Intelligent agents are still in its infancy. It is more of an exploratory research than a solid body of results. As we ponder the future of this field of artificial intelligence, it is important to define a schematic diagram for the practice of IAs. However, the scope and framework of intelligent agents are not yet fully defined. Based on our literature survey, we envision a procedure for the IAs to be built with AI functions that can interact with the real world as described by the schematic flowchart in Fig. 1. From the figure, it can be seen that the IAs can be started from the establishment of sensors and actuators to interact with the environment, then a computer interface to do data acquisition and control output, then a CPU-like artificial intelligence chip with the aid of big data database and world model to do deep learning and intelligent control. The world model can be trained quickly in an unsupervised manner to learn a compressed spatial and temporal representation of the environment. By using features extracted from the world model as inputs to an agent, the IAs can be trained to solve the required task. They can be even trained entirely inside of their own hallucinated dream generated by the world model, to transfer this strategy back into

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the actual environment [3].The big data database can be used to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software [4]. There are six main factors that characterizes the performance of Intelligent Agents as shown below:

A. Autonomy

What mostly sets Intelligent Agents apart from an ordinary program code is the agent's ability to take initiative and control its own actions in order to complete its goals. They are capable of tasks selections, prioritization, goal-oriented behavior, decision making without human intervention. Furthermore, they must be able to accept complex and dynamic requests, and decide for itself how best to satisfy it.

There are several ways that the agent can interact with the request; the agent can modify it if prompted to do so, ask for clarification to gather more information, or even refuse to complete it if the refusal takes precedence over the request. For example, if the user prompts the agent to commit murder, this would violate one of Isaac Asimov's three laws and the agent should be able to recognize that and refuse to comply. This ability to make decisions and prioritize demonstrates a higher level of cognition that separates an Intelligent Agent from other forms of software.

B. Continual Operation

Most agents are continuously running, and only activate its interface in response to an external stimuli. This period in which the agent does not interact with the user is mainly devoted to processing data and gathering more information from its surroundings. The task of a IA which is able to do continuous operation is to find out which sequence of actions will get it to a goal state. Before this, it needs to decide the various input problem an IA to be consider.

Generally, continuous operation by an IA involves several immediate options of unknown value to examine different possible sequence of actions which lead to state of known value. It will then choose the best sequence. The process for such a sequence seeking is called search. The search engine puts a problem as input and returns a solution in the form of an action sequence. This algorithm recommends an action and the phase doing this is called the execution phase. A simple continuous operation agent is able to formulate a goal and a problem, then searches for a sequence of actions that would solve and executes the actions for the problem at same time.

C. Personality

Having a distinct personality greatly increases its appeal and positively benefits its relationship with the user. Being likeable also increases the chances of users giving the agent more information. In this application, the personalized IAs observe the actions of their owners, interact with him/her and attempt to learn by imitation, or direct get the feedback from the users that help the IAs to automate and perform tasks in the same way as their owners.

D. Collaboration

An Intelligent Agent should be adapted at collaborating and communicating with users and other agents alike in order to achieve its goal. The IAs should allow for the interconnection and interoperation of multiple existing IA systems. Therefore the multi-IA systems would remain useful to incorporate them into a cooperating agent community in which they can be exploited by other pieces of software for multitasks or large tasks which are beyond the capability of a single IA.

Research on collaborative systems aims at integrating models and algorithms with hardware to develop autonomous systems that can work collaboratively with other systems and with humans. This research relies on developing formal models of collaboration, and studies the capabilities needed for systems to become effective partners. There is growing interest in applications that can utilize the complementary strengths of humans and machines—for humans to help AI systems to overcome their limitations, and for the intelligent agents to augment human abilities and activities.

E. Adaptability

Intelligent Agents should have the ability to gather and store information on its user's preferences, and to adjust itself accordingly in future trials. It is the adaptability of the IAs. The characteristics of such a system are that its components may not be known previously and may change over time. It could also consist of heterogeneous agents implemented by different people, with different tools and techniques, which can be viewed as a large, distributed information resource.

The next generation of IA technology will include information gathering and sophisticated reasoning in support of solving adaptive problems. For this cooperation and coordination among the agent is essential. In addition, these capabilities will allow agents to increase the problem solving scope of single agents.

III. Prerequisites

A. Robot Prejudice

Mainly because of science fiction in mainstream media, Intelligent Agents and Artificial Intelligence in general have gathered a somewhat unfavorable reputation. When most think about smart robots, they are usually associated with stories of an Artificially Intelligent system becoming too intelligent and deciding that humans must be exterminated in order to save the planet. Because of this preexisting stigma, it is absolutely essential to build safeguards within Intelligent Agents in order to prevent runaway computation. The agent should actively seek to maintain the user's privacy, and should also hide its complexity while simultaneously revealing underlying options; the user must be able to feel in control of the robot at all times.

B. The Uncanny Valley

The Uncanny Valley describes a feeling of uneasiness when presented with something that seems almost human, but isn't quite so [5]. The act of initially perceiving something as human, then slowly realizing that it's not, contributes to this unsettling feeling. This concept was first introduced by Masahiro Mori, who focused on the Vally's effect on robots. He insisted that when designing anything it is absolutely crucial not to fall into the Uncanny Valley, and that to avoid doing so it is best to make it as non humanoid as possible. Mori gives the example of glasses; they are so effective and successful since they don't resemble actual eyeballs, although they retain the same purpose.

When creating a medium in which to place an intelligent agent in, special care must be take in order to avoid the Uncanny Valley at all costs. While we do not necessarily have to completely follow Mori's advice and create only non humanoid automation, if we were to create a machine that resembles an actual human, we would have to capture it perfectly.

IV. Problems And Concerns

One of the most important properties of an IA is its intelligence. An intelligent program that can eliminate the need to perform many basic functions, giving us more time to focus on important tasks, sounds too good to be true, and it might be. Despite the idea's commendable ambition, there certainly are many valid concerns towards developing this technology.

A. Jobs Take, Jobs Gained

The biggest argument against developing technology that can carry out menial, repetitive tasks is that the people whose jobs rely on menial tasks will be rendered jobless; the prospect of technology that is currently under development terminating the entirety of the already-diminishing working class can easily frighten many, and with good reason. It is certainly understandable why these people are afraid; people inherently fear what they do not know, but there are many factors that they are not taking into account.

Although many people believe that companies will soon replace imperfect people with foolproof technology, they do not take into account the jobs that this technology would generate. Yes, many factories that rely on assembly-line manufacturing could potentially replace many workers with robots. However, if one niche is suddenly created, then other niches must be established in order to respond to it. The appearance of robots in factories would generate more complex jobs, such as mechanical maintenance and programming.

B. Interactions

Intelligent Agents are extremely versatile, and can be incorporated into almost any field. It has found an active application in the interaction agents for the daily life,such as Personal Assistants/Organizers;Financial Decision Systems; Home Entertainment; Tutorial Systems; Miscellaneous Aids, etc. Gartner® predicts that 20% people in the developed nations will use AI assistants to help them with an array of operational tasks. It further forcasts that 30% of customer experiences will be handled by conversational intelligent agents by 2022,, up from just 3% in 2017 [6].

V. Real Life Examples

A. Guardian

Since even skilled clinicians are imperfect and are prone to making mistakes that endanger lives, efforts have been made to improve Intensive Care Unit (ICU) monitoring by utilizing computer technology. Guardian is a medical system designed to perform tasks that require knowledge and skill in the ICU. Using multiple different algorithms, it must produce diagnoses and treatment plans under hard real-time conditions [7].

Prior to the Guardian, the goal of similar technology had been to either produce short term solutions to specific problems, or to do basic research on fundamental issues. However, the goals of the Guardian are far more intensive and hands-on; the Guardian strives to perform and coordinate a range of intelligent reasoning tasks of use in ICU monitoring, be reliable in a significant range of medical situations, and scale up to meet the comprehensive set of practical requirements with an appropriate developmental effort. However, at present the Guardian is still in a developmental stage. Programmers plan to extend the depth of its medical knowledge and reasoning skills, demonstrate and evaluate the Guardian's expanding competence on a series of increasingly challenging ICU scenarios, and eventually move on to live trials after a successful test and an appropriately long engineering and development phase.

B. JACK

The JACK is a third generation framework, designed as a set of lightweight components with high performance and strong data typing. Programmers built JACK with the intention of commercial, industrial, and research applications, and they had four goals in mind: provide developers with a stable, lightweight product, satisfy a variety of practical application needs, ease technology transfer from research to industry, and to enable further applied research [8].

The JACK provides a framework that takes a solution found in Artificial Intelligence into practical use. Compared to its predecessors, JACK is not a pure AI system, as it combines the vision of Intelligent Agent research and the needs of Software Engineering. Because of this, JACK provides benefits to both the software engineer and to the academic researcher.

C. Multi-Agent Systems

Multi-agent system (MAS) is an integration of multiple agents into one system. MAS can be defined as a loosely coupled network of problem solvers that are coordinated to solve complex real world problems that are beyond the capabilities or knowledge of each IA.

There are three layers in the architectures of Multi Agent system. At the first level, it is typically a reactive layer to make decisions on what to do, in response to the inputs from the sensors. The second level extracts the abstracts from the raw sensor input and reasons with a knowledge-level view of the Agent's environment. The third level further deals with the group decisions on the environment by the IAs involved in the MAS. The multi agent systems are cooperative and competitive. They can improve their coherence by planning their actions. Planning for a single agent is a process of constructing a sequence of actions. On the other hand, the planning in a MAS environment needs to consider the difficulties that the other IAs' activities place on an agent's choice of actions.

Multi-agent systems are rapidly expanding in many human-computer interactive environments. Although MAS possess many obvious advantages, they also present several challenges, which are counted below [9]:

(i) To formulate, describe, decompose, and allocate problems and synthesize results among a group of intelligent agents.

(ii) To enable IAs to communicate and interact. Selection of communication languages and protocols.

(iii) To inter operate the heterogeneous IAs interoperate.

(iv) To ensure the intelligent agents act coherently in making decisions or taking action, accommodating the non-local effects.

(v) To ensure that MAS does not become resource bounded.

(vi) To avoid unstable system performance.

(vii) To enable individual IAs to represent and reason about the actions, plans, and knowledge of other agents to coordinate with them.

(viii) To recognize and reconcile disparate viewpoints and conflicting intentions among various architecture of IAs trying to coordinate their actions.

(ix) To engineer and constrain practical distributed AI systems.

D. DA VINCI SYSTEM

The da Vinci Surgical System is a robotic surgical system approved by the Food and Drug Administration (FDA) in 2000 to facilitate complex surgery using a minimally invasive approach. This kind of intelligent surgical agents is remotely controlled by a surgeon from a console. The system is now used commonly for prostatectomies, and increasingly for cardiac valve repair and gynecologic surgical procedures[10,11]. According to the manufacturer, the American company Intuitive Surgical, the intelligent surgical System is named "da Vinci" because Leonardo da Vinci's "study of human anatomy eventually led to the design of the first known robot in history." [12] The da Vinci system is capable of 3D visualization in an ergonomic platform. It is taken as the standard of medical care in multiple laparoscopic procedures with the total operations for about 750,000 persons per year. The smart systems provide not only a physical platform for surgery, but also a new data platform for training of the surgical processes.

As long as the patient can get access to a da Vinci System, it is possible to do long-distance operation. Technically the system could allow a doctor to perform telesurgery on a patient in another country. In 2001, Dr. Marescaux and a team from IRCAD used a combination of high-speed fiber-optic connection with an average delay of 155 ms with advanced asynchronous transfer mode (ATM) and a Zeus telemanipulator to successfully perform the first transatlantic surgical procedure, covering the distance between New York and Strasbourg. The event was considered a milestone of remote telesurgery. [13]

The da Vinci provides the insight into how medical physicians carry out the process of interventional medical care. The presence of the da Vinci system in daily operations has also opened the doors to new types of innovation—from new instrumentation to image fusion to novel biomarkers—creating its own innovation ecosystem. The success of the platform has inspired potential competitors in robotic surgery. There are likely to be many more, each exploring a unique niche or space and building out an ecosystem of sensing, data analytics, augmentation, and automation.

VI. FUTURE APPLICATIONS

In many of the smart city domain, AI continues to deliver important benefits to the modern society. Based on the achievement on the R & D for the AI systems, we expect an increasing interest in the development of systems that are human-aware, meaning that they specifically model, and are specifically designed for, the characteristics of the people with whom they are meant to interact. There is a lot of interest in trying to find new, creative ways to develop interactive and scalable ways to teach IAs. Also, system integration of devices, big data and the cloud is becoming more and more popular, as with the thinking about social and economic dimensions of AI. In the coming years, new perception/object recognition capabilities and robotic platforms that are human-safe will grow, as will data-driven products and their markets.

AI advancements are often inspired by mechanical innovations, which in turn promote the development of new AI techniques. Over the last couple of decades, coincident advances in both mechanical and AI technologies have enhanced the safe and reliable use and utility of home robots (part of the intelligent agents). IAs for special purposes will be developed to deliver packages, clean offices, and enhance security, but technical constraints and the high costs of reliable mechanical devices will continue to limit commercial opportunities to narrowly defined applications in the near future. As with self-driving cars and other new transportation machines, the difficulty of creating reliable, market-ready hardware should not be underestimated.

AI is likely to have a more significant impact on urban infrastructure in support of the establishment of the smart city. For this purpose, accurate predictive models of individuals' movements, their preferences, their goals and even their personality are likely to emerge with the greater availability of data to obtain more "personalized" intelligent agents.

A natural requirement that arises in interactive environments for intelligent agents is manipulation. Recent AI revolution in machine learning is now started to influence robotics, in part because it is more difficult to acquire the large labeled data sets that have driven other learning-based areas of AI. Reinforcement learning, which obviates the requirement of labeled data, may help bridge this gap but requires systems to be able to safely explore a policy space without committing errors that harm the system itself or others. Advances in reliable machine perception, including computer vision, force, and tactile perception, much of which will be driven by machine learning, will continue to be key enablers to advancing the capabilities of robotics.

VII. CONCLUSION

From the review, it can be seen that an intelligent agent may be defined as an autonomous independent entity which is able to sense the environment around it, design its behaviour and take actions in accomplishing goal. It can adapt itself to the environment with high degree of authority. It is also capable of scheduling its plan of action to maximize the rate of success. An IA can be a biologic entity, robotic or computational. The field of intelligent agents is a vibrant and rapidly expanding area of research and development. It represents multi-disciplinary efforts on the AI applications, using distributed computing, object oriented systems, software engineering, artificial intelligence, systems engineering. So far there is no standard method for exploring the capabilities and uses of the intelligent agent systems.

From its primitive days, AI has taken up the design and construction of systems that are embodied in the real world, just like process control systems for automation. The area of intelligent agents investigates fundamental aspects of sensing and acting, in particular their integration, to enable an IA to behave effectively. Since the IAs share the real world with human beings, the specialized subject of Human-IA Interaction has also become prominent in recent design.

As more and more intelligent systems have been built, a natural question to be asked is how such systems will interact with each other. The field of Multi-Agent Systems will address this issue, which is becoming increasingly important in on-line marketplaces and transportation systems for the smart cities.

References

[1] Etzioni O., and D.S. Weld. 1995. "Intelligent agents on the internet: Fact, fiction, and forecast." IEEE Intelligent Systems 4 : 44-49.

[2] Norman, D.,1994. “How might People Interact with Agents”. Communications of the ACM, 37(7): 31-40.

[3] Russell, S.J.; Norvig, P. 2003, “Artificial Intelligence: A Modern Approach” (2nd ed.), Upper Saddle River, New Jersey: Prentice Hall, ISBN 0-13-790395-2, chpt. 2

[4] Vanita, K., 2018. “Intelligent agent: A review”. International Journal of Advanced Science and Research. 3(1): 93-96

[5] Mori, M., MacDorman, K.F. and N. Kageki. 2012. "The Uncanny Valley [from the Field]." IEEE Robotics & Automation Magazine, 19(2): 98-100.

[6] Garner®, https://www.gartner.com/smarterwithgartner /use-ai-to-make-cities-smarter/

[7] Hayes-Roth, B., et al., 1992. "Guardian: A prototype intelligent agent for intensive-care monitoring." Artificial Intelligence in Medicine 4(2): 165-185.

[8] Howden, Nick, et al. 2001. "JACK intelligent agents-summary of an agent infrastructure." 5th International conference on autonomous agents.

[9] Lokanath S., and Chittaranjan P., 2010. “A Review on Intelligent Agent Systems”. Int. J. of Computer and Communication Technology, 2,(1): 42-57

[10] "Robots as surgical enablers". MarketWatch. 3 February 2005. Retrieved 17 March 2013.

[11] Jump up to: a b c "Prepping Robots to Perform Surgery". The New York Times. 4 May 2008. Retrieved 17 March 2013.

[12] "Company – Past Present Future". Intuitive Surgical. Retrieved 14 January 2015.

[13] Marescaux, Jacques; Leroy, Joel; Gagner, Michel; Rubino, Francesco; Mutter, Didier; Vix, Michel; Butner, Steven E.; Smith, Michelle K. (27 September 2001). "Transatlantic robot-assisted telesurgery". Nature. 413 (6854): 379–380. doi:10.1038/35096636 – via www.nature.com