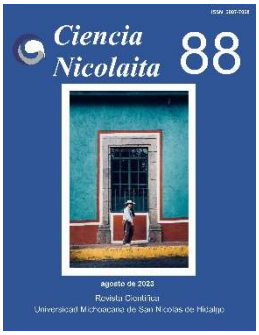

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Augmented intelligence: Origin, value and future prospects

Inteligencia aumentada: Origen, valor y perspectivas de futuro

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Abstract

This essay presents a brief review of the origin of artificial intelligence as a preamble to augmented intelligence, as well as its definition and a series of applications with the intention of demonstrating the value generated by augmented intelligence for human beings. The examples refer to its use in daily life, industry and manufacturing, health care, and includes autonomous vehicles as one of the most attractive uses. Also, some proposals are shared to encourage its wide and widespread use, concluding with a brief perspective on the future of augmented intelligence.

Keywords: artificial intelligence, human intelligence, augmented intelligence applications, policies and standards.

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Introduction

In 1997, the IBM-built supercomputer Deep Blue defeated world chess champion Garry Kasparov by a total of 3½ to 2½ in a best-of-six-game match, but Kasparov was not satisfied with the results and claimed that in the last game, the one that decided the match, there had been human intervention in a Deep Blue move. Kasparov was playing with Black and offered to give up a pawn to initiate a counterattack, but the computer refused the sacrifice. According to Kasparov, the computer was programmed to accept the sacrifice and there was interference from some human advisor who decided to reject it. Kasparov later demanded the publication of Deep Blue's process logs. IBM agreed, but then failed to do so. Kasparov then denounced that IBM had cheated and that the match had been organized for propaganda purposes (Goodman & Keene, 1997). The above situation reveals the possibility that machines alone have a great capacity, but if their potential is combined with human possibilities, a far superior duo is generated.

Artificial intelligence (AI) is conceived according to Ganzarski (2017) as the creation of a machine that can replace and perform tasks that normally require human intelligence and reasoning. Another term that is less frequently mentioned is augmented intelligence (AuI), which is conceptualized as an alternative to AI that focuses on the assistive function, emphasizing the fact that it is designed to enhance human intelligence rather than replace it (Rouse, 2018). Both intelligences are related to humans and life today, there is little familiarity with AuI; therefore, it is useful to understand details and data on how it brings value to human endeavors in such a way that it is possible to understand and establish ways and mechanisms to continue to use to enhance its ability to improve life and its challenges.

In accordance with the idea expressed forward, the objective of this essay is to understand the value that AuI can bring to human activities, showing the benefits that can be obtained from it through examples. Subsequently, the mechanisms that are basic to continue using AuI will be presented, and finally, a brief perspective on the future of AuI will be considered.

Development

It will start by briefly reviewing the history around the emergence of AI. In 1931, Kurt Gödel laid the foundations of Theoretical Computer Science and AI by publishing the first universal formal language for creating provers of computational theorems. In the early 1950 the link between human and machine intelligence was really observed, the term “Artificial Intelligence” was introduced in 1956 by John McCarthy and since then AI has expanded. In 1961 the industrial robot UNIMATE was born, it went to work at GM replacing humans on the assembly line. In the 1990, research on AI and its applications focused on areas such as logistics and medical diagnostics with the help of data mining. In 2011, recommendation technology gave rise to Siri, an intelligent virtual assistant with voice interface, integrated by Apple in the iPhone 4S. Eugene Goostman, a chatbot passes the Turing Test with a third of the judges believing Eugene was human in 2014. In 2016, the market for AI-related products reached more than $8 billion in the USA (Lukač *et al*., 2018). The development of AI once it came into existence has been very fast, all the above occurred in less than 70 years, and still continues. A timeline of this evolution is shown in **Figure 1**.

This speed is evident if it is considered that the hunter-gatherer period lasted several million years, the agricultural era lasted several thousand years, the industrial era lasted a couple of centuries and the information era lasted a few decades (Conti, 2017). Thus, as a result of all that has been previously learned and generated by human beings in addition to recent discoveries and developments in AI, humanity has reached a new age: the augmented era.

To reference the emergence of AuI, we should consider IBM, this company has been exploring, creating, and dedicating resources to AI innovation for over 50 years and for this they have been guided by the term “augmented intelligence” as opposed to “artificial intelligence”. It takes the best of human intuition and imagination and combines it with the ability of AI to maintain scale and access an early warning system for the organization that leads to predicting things that could go wrong (Sharma, 2019).

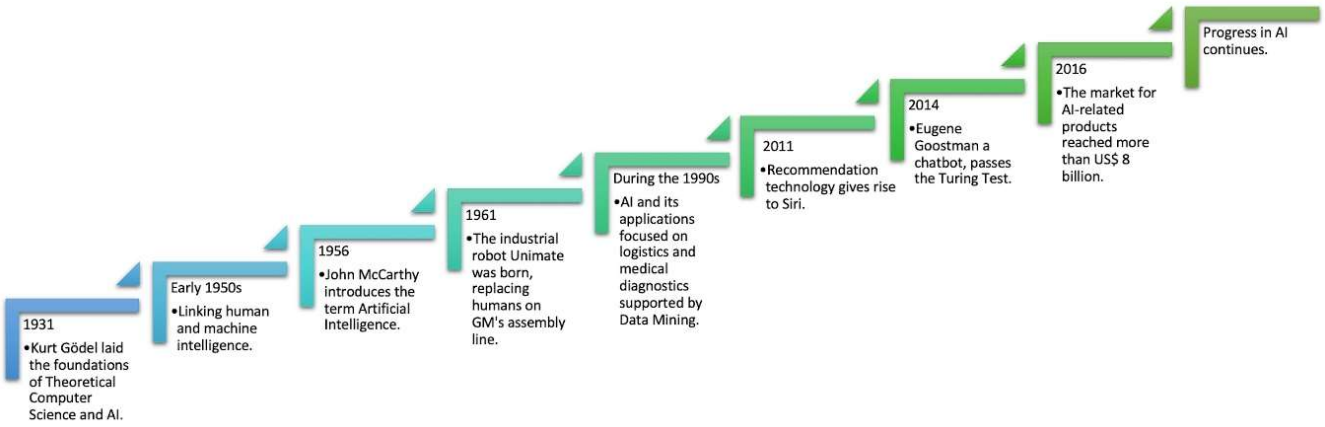

Figure 1. Evolution of AI from 1931 to 2016. Note: Adapted from "From Artificial Intelligence to Augmented Age an Overview", by Lukač *et al*., 2018.

AuI is a step forward with respect to AI, it is the result of many inventions that are already in the lives enhancing the capabilities. Whether it is talked about self-driving cars as generative design programs, high-tech robotics, or object recognition software, in the end, human capabilities are being enhanced with computational systems that support people think, robotic systems that help to do, and digital nervous systems that connect people to the world beyond the natural senses. One such example is the intelligent personal assistant called Siri. It can detect voice commands and a natural language user interface to answer questions, make recommendations and perform actions by delegating requests to a set of Internet services (Lukač *et al*., 2018). Table 1 shows a brief reflection on the most significant differences between the two intelligences and the most important implication related to these technologies.

To demonstrate the usefulness and value that AuI provides to today's life, several applications of AuI will be presented:

Brain- computer interfaces: These allow users to operate external devices by thought, such as controlling robots and devices in smart homes. Traditionally, an electrode has been used to detect brainwave signals and identify imaginary motor commands, but this can be cumbersome. With an AuI approach, it was decided to place biosensors at discrete locations on the user's face to measure physiological signals to detect various eye movements and facial expressions, this allows users to operate external devices using their own eyes and facial gestures (Wang *et al*., 2017).

Table 1
Differences and implications for AI and AuI.

Artificial intelligence	Augmented intelligence
AI replaces human intelligence and creates machines that work and behave like humans, making human intervention unnecessary.	AuI does not seek to replace human intelligence, its objective is to support people's reasoning process and decision making.
AI is a tool, not an end, it has been around for decades, acquiring significant new capabilities, driven by computing power	AuI involves integrating human intelligence with AI to create a virtuous coexistence and strengthen the role of people in driving growth.
Important implications of both intelligences	
AI and AuI pose risks to privacy, freedom, security and discrimination. Therefore, both intelligences require an inclusive dialogue involving all countries, focused on the right way to use these new technologies.	

Note: Adapted from "Artificial Intelligence or Augmented Intelligence? Impact on our lives, rights and ethics", by De Felice *et al*. (2022).

Speech recognition systems: Enable speech prediction. Generally, speech recognition systems use acoustic features without considering the users' context as well as sentiment and surrounding environment, which reduces recognition accuracy and human touch in responses (or being robotic). The proposed AuI approach has been shown to improve recognition accuracy as it receives speech as well as sentiment and environmental information to improve recognition accuracy (Hebbar, 2017).

Social edge intelligence: Collects human input through crowdsourcing, explores the wisdom and collaboration of ordinary individuals-without the involvement of third parties and regulatory bodies and then uses AI to perform tasks. For example, social edge intelligence uses eyewitness edge devices to collect images of damaged scenes through crowdsourcing, and then uses AI to assess the level of damage caused by a catastrophe (earthquakes, wildfires, floods, etc.) which helps guide rescue teams to areas of concern. AuI approaches improve overall system performance, i.e., reduced response delay by crowdsourcing and increased response accuracy (Wang *et al*., 2017).

Examples of the use of AuI in industry and manufacturing systems:

New product design: AuI is used to design new products using (a) human intelligence to introduce creativity and fuzzy reasoning without the need for a complete model of complex engineering processes; and (b) AI to provide accurate computation and execute repeated and procedural tasks with reduced time and cost. The proposed AuI approach helps human designers to incorporate their knowledge, experience, and inspiration into designs (Yu *et al*., 2004).

Packaging designs: AuI is used in 2D packaging to maximize the number of objects with irregular shapes and sizes in a rectangular 2D container, where objects should not overlap. The proposed AuI approach has been shown to increase space efficiency (Agrawal *et al*., 2015).

Telerobotic system: Combines human and machine commands to generate a single joint command to control robots (i.e., a robotic arm), which is useful in manufacturing plants and hazardous environments. The joint command must not exceed the maximum operating parameters of the system, such as maximum speed and acceleration. The joint command moves the robotic arm, and the motion is observed by both the human and the machine. The proposed AuI can avoid unexpected obstacles, achieve accurate position tracking, and ensure smooth motion, while reducing human involvement and skill requirements (Guo *et al*., 1995).

Fault detection: Detects and diagnoses or identifies the root cause of faults, as well as performs troubleshooting, in large chemical and manufacturing plants in real time. The results of the fault detection system notify human operators to take appropriate corrective action to ensure operations return to normal. It has been a challenge for human operators to evaluate a massive amount of data generated by many sensors and instruments in plants with the shortest possible delay. Meanwhile, although AI can process a massive amount of data, it has several shortcomings. The proposed AuI approach has been shown to increase the accuracy of fault detection and diagnosis (El Koujok *et al*., 2021).

Employee training: Training is often aimed at transferring knowledge from experienced employees to new employees. One of the main problems is that implicit and experience-based knowledge cannot be transmitted orally and in written form. Therefore, designing a complete AI-based automated system for training is difficult and complex, as different behaviors and personalities must be modeled. Implicit knowledge is learned through imitation, in which the behaviors of experienced employees are compared with some known sequences of actions. Second, during the training session of the inexperienced employees, the proposed training system provides feedback (i.e., the quality and speed of the execution process) to the inexperienced employees based on the learned knowledge. The AuI approach helps to facilitate the employee training process (Maettig & Foot, 2020).

In the area of healthcare, AuI has also developed and is collaborating in two very important situations:

Disease detection: AuI is used to detect colorectal polyps in colon cancer screening. Highly trained medical professionals are responsible for distinguishing between true and false colorectal polyps on CT images. Whereas AI uses computer-aided detection software. AuI has been shown to increase colorectal polyp detection compared to human intelligence and AI approaches separately (Wang *et al*., 2011).

Estimating medication dosage: Scientists and clinicians have faced difficulties in determining the appropriate dose of medication at which patients may respond to treatment. Linear parametric models have been used to estimate dose-response relationships; however, there are limitations, such as the lack of concern for effects and the complexity of a patient's physiology. AI fine-tunes the dose administered by the physician to optimize an objective function based on various factors, such as prescribed intravenous dose, demographics, blood pressure, etc., to maximize the chances of survival. The AuI approach increases the survival rate by up to 22 % among patients diagnosed with sepsis (Gupta *et al*., 2021).

The last example corresponds to self-driving cars, which attract a lot of attention because their advent was long awaited and full of fantasies animated by science fiction. Today they exist and, in their progress, AuI has played a preponderant role.

As many people lose their lives in traffic accidents every year due to human factors (e.g., driver distraction and misjudgment), interest in self-driving cars has increased. A driver defense system based on the human intelligence and AI model monitors drivers, learns their behaviors, and interacts with them to prevent accidents. There are two main steps: first, based on human intelligence, the physical parameters of the car, such as location, speed, acceleration, and position, are collected; second, the physical parameters are fed into the AI so that it learns to adapt to each driver's unique driving behavior. The proposed AuI helps to smooth the driving experience, for example, by avoiding early warnings that can irritate drivers (Hwang *et al*., 2003). For AuI to continue its development and implementation, it is necessary to establish policies or guidelines that allow its use to be adequate and harmonize with the progress of human activities.

Various authorities and professional bodies have developed policies to support the design, evaluation, and implementation of AuI. For example, in the healthcare setting, the American Academy of Dermatology published a workflow for developing AuI applied to dermatology. The workflow involves physicians and consists of four steps. First, the data collection stage consists of collecting and labeling high-quality data that represents the target population. Second, the model development stage uses the input data and known output datasets to train an AuI model, and then uses an independent test dataset to validate the model. Fourth, the new data stage, which is used to refine and improve the model to maintain a continuous guarantee of satisfaction (Yau *et al*., 2021). The model described above involves a series of guidelines that have been tested and allow this area to have an established working scheme that can even be used in other sectors and thus promote the proper use of a tool such as AuI.

As for what is possible to envision into the future, it is noticeable that AuI systems will likely be indispensable in the coming years. There is an environment in which AuI can be applied naturally, for example, AI can collect data from radiographs, diagnoses, and previous reports and perform analysis, then doctors use the data to make judgments, in this way AuI is employed and doctors can spend more time caring for patients. In general, AuI can be used when AI is employed and when there is a need to increase cognitive abilities and reduce a person's bias.

There is a wide range of future applications of AuI, particularly data-driven applications, such as those in the fields of education, entertainment such as gaming, automotive, healthcare, defense, and smart agriculture (Yau *et al*., 2021). The multiple possibilities presented by AuI and the ease with which it can be used make it a mechanism that effectively enhances our capabilities without replacing the human being as such, and this innovation is being updated in every field in an effective way with extraordinary results.

In addition to the benefits that have been evidenced, it is valuable to consider that the growth in the development and use of AuI presents challenges for which human beings must be prepared, basically it is necessary to have academic preparation, training and greater openness within organizations for its implementation in them (De Felice *et al*., 2022).

Conclusions

The evolution of AI has been very fast, in a relatively short time it has advanced very significantly, especially when compared to other important advances in human development. In this evolution, AuI has emerged, which takes the best of AI and human intelligence, overtaking them and bringing in a new era. In these new times, very attractive solutions have emerged, from autonomous cars to object recognition

software, among many other possibilities, all favoring our human capabilities.

To demonstrate the value that AuI is producing in our lives, examples were shown such as brain-computer interfaces that enable users to manage external devices through thought, speech recognition systems that consider sentiment and environmental information, and social edge intelligence that helps to save lives. In the case of industry and manufacturing, examples were presented such as the support it provides to the design processes of new products, as well as packaging, telerobotic systems to control robots with human-machine intervention, fault detection systems and even personnel training. In relation to health care, its assistance in fundamental activities such as diagnosis and estimation of the dosage of drugs for patients with sepsis was evidenced. Finally, the development of autonomous vehicles was presented, which includes a driver defense system based on the human intelligence model and AI, which monitors drivers and learns. All these examples show the value that AuI is adding to the tasks of humans in different areas.

To ensure that AuI continues evolving and be used widely and broadly, it is essential that policies and standards be established. The setting of policies must involve both authorities and personnel involved, which implies that diverse perspectives and points of view are required for the rules to be fair and accurate. With respect to standards, it is necessary to analyze the steps and processes required at each stage, so that adequate standards can be proposed to ensure results and protect those involved.

Regarding the future of AuI, there are too many possibilities in areas ranging from education and entertainment to healthcare and intelligent agriculture; all of them involve humans and AI. Therefore, new proposals and solutions that continue to contribute to human life and to the progress of AuI itself will surely be seen in the short term.

It is possible to conclude that the development of AuI implies a step forward for AI, that its use is increasingly natural because it effectively enhances capabilities and eliminates human biases, i.e. it suppresses errors and helps purely human capabilities such as imagination, judgments and creativity to reach a much higher level. AuI has shown that it manages to take the best of AI and human intelligence to generate results far superior to what each can achieve independently.

There are still many research challenges ahead for AuI, but what already exists invites to continue favoring this area, which has demonstrated exceptional capabilities.

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