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Walking Through the Turing Wall

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Abstract: Can the machines that play board games or recognize images only in the comfort of the virtual world be intelligent? To become reliable and convenient assistants to humans, machines need to learn how to act and communicate in the physical reality, just like people do. The authors propose two novel ways of designing and building Artificial General Intelligence (AGI). The first one seeks to unify all participants at any instance of the Turing test – the judge, the machine, the human subject as well as the means of observation instead of building a separating wall. The second one aims to design AGI programs in such a way so that they can move in various environments. The authors of the article thoroughly discuss four areas of interaction for robots with AGI and introduce a new idea of techno-umwelt bridging artificial intelligence with biology in a new way.

Keywords: artificial intelligence, the Turing test, post-Turing methodology, techno-umwelt, intelligent robotics, general artificial intelligence, AGI.

1. INTRODUCTION

The paper “Computing Machinery and Intelligence” by A. Turing was first published in 1950. It was quite a long time ago. A lot of people may still remember the age when we had no computers. But it is crucial to look at the past because when we recall the past we see that it serves the present. Today it gives us fresh insights on what we sometimes overlook and draws our attention to ideas that might have been skipped for some reason. It also can give us some new perspectives to look from and that is why we look back there for new ideas.

However, the history of the idea of a human-like creature, endowed with artificial intelligence, is coming from much older times than science-fiction fans believe, attributing the idea of robots to Karl Czapek who coined this term in the twenties of the last century. The legend about a man-made creature capable of everything that a man can do comes from extreme antiquity. We read about it in the works of Chuang Tzu, a Taoist from Ancient China, in the ancient Greek myths about Pygmalion, and "smart" tripods-assistants of Hephaestus. Aristotle seriously considered the "automation" of reasoning and described syllogisms - logical premises and conclusions that serve as elementary building blocks of rational thinking. Another important milestone on this path was the work by Gottfried Leibniz, who at the end of the 17th century not only laid the foundations of mathematical logic, but also talked a lot about the possibilities of algorithmic thinking.

At the end of the XVII century, Leibniz described the concept of ratiocinator - a logical system that allows us to express any derivative concepts clearly and simply, using basic elementary concepts and strict rules, and performing operations on them that resemble mathematical ones. The idea of creating such a "philosophical machine" was grand, but due to the underdevelopment of technology, it remained unrealized for many years. The first significant step towards this was taken only in the 1830s when Charles Babbage tried to construct an "analytical engine", a mechanical prototype of modern programmable computers. The outcome was not very successful but the attempts to "mechanize" thinking has not stopped.

In the 1930s, Kurt Gödel formulated and then proved incompleteness theorems, according to which no system of formal arithmetic can be complete and internally consistent at the same time. In other words, there is no such system that allows one to prove or disprove any given statement. This had puzzled many researchers for a while. But soon Alan Turing and Alonzo Church introduced the concept of computable function (solved in one system or another) and showed that all functions can be solved not through formulas but algorithmically, for example, using a Turing machine (Turing, 1936). Turing’s thesis, in its simplest form, says that a universal Turing machine can perform any computation that a human can do (Turing, 1937). This idea, surprising in its simplicity and depth, paved the way for the emergence of the first computers, on which Turing himself worked during the Second World War. At that time the British scientist thought of creating an "intelligent machine" (intelligent machine). The term "artificial intelligence" was not yet coined.

A lot of effort is being put by various institutions at the national level into building Artificial General Intelligence. Notably, in Russia Sberbank, a leading Russian technology corporation, has launched a large-scale AGI research program, attracting the world’s top talent like J. Schmidhuber (Efimov et al, 2021). The authors of this paper are working on the philosophy and methodology of the AGI research program and want to share their views on it. Particularly, we have jointly developed some novel approaches to cognitive architecture for the future AGI. It might be useful to facilitate some fruitful

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outcomes of combining the Narrow AI approach and a more general one.

In recent years, the actual issues of AI development have been widely discussed at high-level conferences like Artificial General Intelligence (Goertzel et al, 2019), Robophilosophy (Coeckelbergh et al, 2018) and some others. Notably, the issues raised by Turing 70 years ago provoked some discussions at an important conference "Beyond Turing" (Marcus et al, 2015). It was organized by G. Marcus and attended by such researchers of artificial intelligence and robotics as B. Lenat, K. Forbus, S. Scheiber, T. Podgio, E. Meires, S. Adams, G. Banavar, M. Campbell, C. Ortiz, L. Zhitnik, A. Agraval, S. Antol, M. Mitchell, H. Kitano, V. Jarrold, G. Marcus, O. Etzioni and others. Many papers in that conference were dedicated to novel ways of testing robotics and artificial intelligence, as well as some substantiated proposals were made on the use of embodied intelligence to create AGI models. Many of these researchers are simply trying to transfer the Turing test methodology by using a robot instead of an abstract computing machine that simulates a human conversation. For example, one of the original ideas from the "Beyond Turing" conference was that of using AI as an independent factor in scientific discoveries. Today, H. Kitano, the head of the AI program at Sony Corporation, believes that the Turing test can no longer be a criterion for creating artificial intelligence and that at the existing level of technology it is possible to develop an "AI system that can make major scientific discoveries in biomedical sciences, and that is worthy of a Nobel Prize" (Kitano, 2016).

Additionally, it is necessary to note some individual works and works done by groups of researchers, such as W. Nöth (Nöth, 2001), A. Clark (Clark, 2001), H. Ishiguro (Ishiguro, 2007), S. Penny (Penny, 2018) et al.

Overall, there are three approaches to a long-term research program in AGI: connectionism, logical representation and embodied intelligence. The authors of this paper take side with the last one, and it is strongly supported in the works of R. Brooks (Brooks, 2018), Clark (Clark, 2020) and many others, who maintain there is a connection between the cognitive functions of intelligence (both of human and a machine) and physicality, and are convinced that the classical view of machine functionalism on the role of representations in cognition is "too cerebral" (Spitzer, 2016). Clark gives an example of a study where the behaviour of female crickets was analyzed and one of its findings was that male crickets used a unique sound source localization system. Clark argues that this process is carried out completely without any internal representations of the surrounding world, relying entirely on the mechanical solution of the problem by the female cricket. Similar mechanisms are used by people to solve everyday problems (Clark, 2001).

Some researchers are bridging robotics and AGI fields with biology and semiotics by making attempts to implement the idea of umwelt for robotics. For example, a robot perceiving the world solely via the radio waves that are emitted and absorbed by radars cannot understand the "red" colour. Thus, a robot might have a kind of a limited umwelt similar to the umwelt of an insect. Few authors agree with this, discussing the issues of umwelt for robots and the semiotic meaning of perception and artificial intelligence (Nöth, 2001). However, their discussion is limited only to the application of robotics to the physical world.

A very thorough discussion on the issues of virtual humans, AI and embodiment can be found in Burden et al (Burden, Savin-Baden, 2019).

AGI as well as robotics are developing very rapidly, and a lot of definitions are improving very rapidly. For the definitions, in search of a clearer understanding of the issues of modern robotics, including intelligent robotics and the use of AI in robotics, one can address Murphy's handbook (Murphy, 2019).

2. CHESS AND CIPHERS

Many experts today believe that before embarking on the creation of artificial intelligence, one should figure out the nature and structure of the natural. However, Turing saw the problem in a completely different way. He inherited the ideas of Rene Descartes, who considered the living organisms as fully automated beings, believing that a fully-fledged consciousness and thinking are only characteristic of humans. In such a world view, the human mind, his intellect is separated from the real world, as a part of a different "sphere of consciousness". Likewise, in the thought of Alan Turing, the intellect practically did not specifically depend on its physical carrier.

In his famous 1950 paper "Computing Machinery and Intelligence," he identified several areas representing the "highest manifestations" of human intelligence that should be modelled in the future (Turing, 1950). They are the study of languages (and translations), games (chess, etc.), mathematics, and cryptography (including solving riddles). If in these fields of activity, a computer cannot be distinguished from a human, - claimed Turing, - then we should consider their thinking as equivalent, and we can say that we are dealing with an "intelligent machine."

Turing didn't think that the most prominent thing in a person was the ability to play chess, conduct sublime dialogues or solve cryptographic riddles. Turing was convinced that to create intelligent machines with abilities comparable to humans, it was not enough just to teach the machine to interact with the physical world. In a 1948 report to the National Physics Laboratory, Turing wrote that such a machine "would not be able to appreciate such things so important to humans as food, sports, or sex" (Turing, 1948). Creating a machine capable of interacting with the real world means to follow the path of a more guaranteed artificial intelligence, while Turing considered this path to be longer and more expensive than teaching a computer to play chess.

It should be mentioned that a couple of years after this publication there appeared a "turtle" by Walter Gray – one of the first autonomous robots. Surprisingly, the very primitive creatures displayed "intelligent" behaviour and could, for example, find their charging station using a phototaxis and guided by the light. This complexity was born as an outcome of direct interaction of the real world with the simplest "consciousness" of robots, and if Turing had written his article later, he would certainly have formulated the problem differently. Although this article was written more than 70 years ago, it set the conceptual foundations for many generations of researchers into artificial intelligence (Ackerman, 2014). According to Turing's approach, high-level brain intelligence functions can be reproduced in an artificial system without imitating the system in the physical world. And the test, described in his article, developed such representations.

3. INSIDE AND OUTSIDE THE WALL

Reflecting on the test, Turing started from the Victorian “imitation game.” According to its rules, a presenter, exchanging notes with the players, must determine who of the players is a woman and who is pretending to be one by exchanging notes with them. Of course, a "referee" does not see them at the same time. He is separated from the players by a wall, impenetrable to everything except for symbolic information, such as notes or, in modern terms, chat messages. This test can be seen as an “intelligence test” for a man who has to imitate "feminine" (of course, in representations of Victorian times) behaviour and reactions. The Turing test transferred this situation to a game with a computer that must simulate a living person hidden from the judge by the same "wall.”

This wall seems to be an indispensable element of the test because without it we will immediately see whom we are dealing with. It hides the physical reality of the conversation partner and reduces his entire thinking down to a certain limited set of processes. At the same time, even Turing himself admitted that a comprehensive human knowledge of the world is impossible without direct interaction with this world. However, at that time, imitating tasks such as doing sports, eating food, or having sex seemed completely unthinkable, so the British scientist postponed them to the indefinitely distant future and suggested focusing on games, languages, and cryptography. As a result, Turing launched a kind of race between a man and a machine exclusively in the virtual space. At the same time, the idea of such a test stimulated the development of the systems that performed certain narrow functions better than humans, whether it was playing chess, translating, or driving a car, and that was even ready to replace us in one area or another. The narrow capabilities of the intellectual machine were originally laid down in the paradigmatic idea of Turing, which limited the intellect only to simple verbal, symbolic communications and ignored all other modalities. Can the intelligence that plays chess, chats, and solves riddles be called a general AI? It is hardly possible...

However, if a machine (a robot or a computer) remains separated from the person and the world by a wall, it is unable to fully interact with them, and the machine's true intelligence is replaced with the complexity of the functions it implements. That is probably enough for an unmanned vehicle or a chess program, but it is not enough in the pursuit of general AI which calls for a paradigm shift. It means that we must “break the wall” and take a step towards a novel post-Turing methodology. The methodology requires that all the elements of the “test” mentioned by Turing should constitute a single whole and be seen as a complex: the observing judge, the subject (a person or a computer), and the questioning tool (the wall turns into a rich interactive environment, a sort of interface between a machine and a person).

4. VERIFICATION BY DATING A GIRL

For an easier explanation of post-Turing methodology, we shall refer to the thought experiment “verification by dating a girl” proposed by Alexeev (Alexeev, 2013). Let us say a young man meets a couple at an online dating platform. Having chosen the appropriate parameters (age, lifestyle, etc.), he receives a list of users and initiates a conversation with one of them. After a long virtual conversation, the young man finally invites the girl out for a date only to discover that he has been chatting to a program all this time. This rather embarrassing discovery is equivalent to artificial intelligence successfully passing the Turing test in its classic version. Expecting technological evolution to follow its current way, Alexeev suggested that “shortly, the ‘Dating Girl’ scenario will also come true” (Alexeev, 2013).

However, even if this scenario is implemented, it will not make any practical sense because it deprives the machine of the comprehensive direct and useful interaction with a man and the world when interacting “through the Turing wall.” To clarify this, let’s imagine a different ending to the scenario in the same experiment. Suppose that the young man meets the girl in a cafe and she looks alive and real. However, the offline conversation does not go so well: it turns out that they do not have so much in common. The young man discovers that the witty and appropriate remarks that the girl was giving when chatting online were automatically prompted by artificial intelligence. Disappointed, the young man goes back home and writes to her that he is embarrassed by such a meeting and feels a little uncomfortable, but she replies with a quote from his favourite TV series, and the interaction is resumed.

Thus, the wall separating interactions between a human and a machine does not bring any value to AGI development. The wall is excessive and is no longer needed to assess the degree of artificial intelligence and its interaction with people. At the same time, a computer turns out to be emotionally closer and more understandable than even a human conversation partner, it is “more humane than a human himself.” In this regard, one can again recall Plato with his “eternal ideas” and real objects as their manifestations. Artificial intelligence, not encumbered by the Turing wall, can embody the “idea of intelligence” in the same way as a person himself does, in its own right and through interaction with a human. A person knows who he is dealing with and realizes that he feels better with a machine: he finds it more interesting, more useful and more reliable.

5. POST-TURING

A real thinking machine should become the product of versatile interactions with humans and the outside world: verbal and non-verbal, taking place both in a virtual environment and in a real one. Therefore, the classical Turing test covers only the areas of verbal and virtual interaction, like Winograd's schemes and most other popular tests of artificial intelligence. This is not surprising, because they all exist within the paradigm set by Turing, i.e. "behind the wall.”

Breaking it down means getting out into the field of non-verbal and real assimilation of the world by artificial intelligence.

Today we realize that many animals possess certain forms of consciousness, including even cephalopods. And each time thinking and its manifestations turn out to be related to the real conditions in which the living creature exists, to the corporeality of the living creature and its motor skills. According to Dubrovsky (Dubrovsky, 2019), mental phenomena has occurred only in those organisms that are active in the external environment. It seems that a complete knowledge of the surrounding world is essentially impossible without physically interacting with it. Therefore, a condition for creating the "general" artificial intelligence will be its capability to work in different modalities and different environments. It needs a gateway to non-verbal and physical fields.

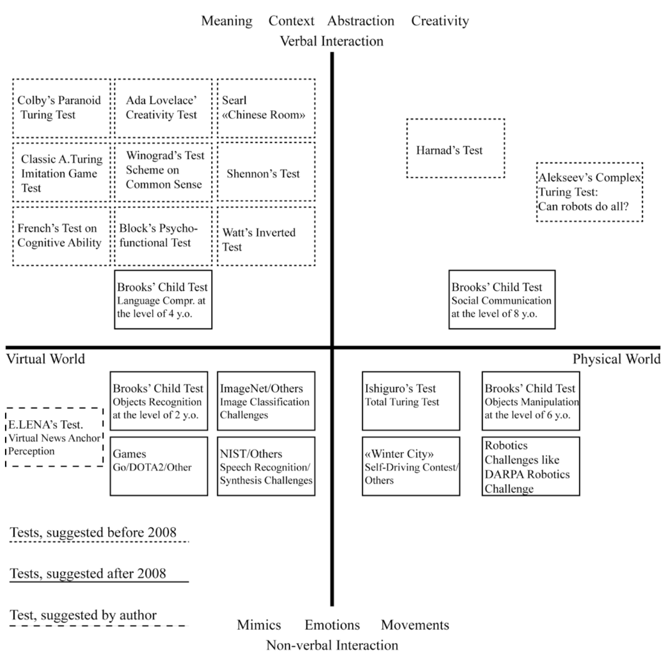

Figure 1. Shows the Turing continuum (Efimov, 2020).

The idea of all kinds of robots (or any machines) interacting in verbal-nonverbal and physical-virtual areas is graphically represented in (Fig.1). Two axes are making up altogether four dimensions from a robot's (or a machine's) perspective: 1) verbal\virtual world; 2) verbal\physical world; 3) non-verbal \virtual world; 4) non-verbal\physical world. These four dimensions (further referred to as "techno-umwelts") cover all possible interactions for all kinds of machines, which is why they are so important and call for a further detailed discussion.

5.1 Verbal Interaction\Virtual World

The history of AI research described in the work shows why the majority of tests (thought experiments) built before 2008 are in this quadrant. Testing various skills of verbal communication is the basis of the canonical Turing test, Lady Lovelace test, Colby test, Searle test, Block test. In all these tests a person acts virtually in the world of his imagination and in the world of a computer program. The interface consists of a standard: display, a keyboard and a mouse. An example of a similar interaction may be a user interaction with a banking program. Casual connections in already existing systems of concepts are the basics of a machine's responses, even if a computer can assess the social motives of the conversation/interaction partner.

5.2 Verbal Interaction\Physical World

There are very few examples of Turing tests in this quadrant as it is very hard to come up with them because we don't have real human-level robotics or artificial general intelligence combined in one universal machine. Essentially, a real robot with a fully-fledged AGI should be tested here, if one is intending to pass any Turing test at all. There are no known successful examples of robots capable of communicating with humans and interacting with the physical world at the same time. R. Brooks (Brooks, 2018) notes that it might take ages before robots get to this quadrant by becoming capable of operating at the level of an 8-year-old child. S. Harnad suggested that his Total Turing test will be placed in this quadrant.

5.3 Non-verbal Interaction\Virtual World

An example of such interaction is the duel between game characters in computer games. Although A. Turing pointed out its importance, this area of tests was long ignored by researchers. Recognition of images, human speech, as well as their synthesis, can be an example of non-verbal interaction in the virtual world. Influence by the physical world is fundamentally absent, and even if a machine recognizes the speech of a person (for example, that of a player) it then determines only the words and ignores their meaning. Actions or emotions of virtual avatars, which carry a heavy semantic load without transmitting any verbal information whatsoever, can be an example of non-verbal interaction in the virtual environment (Efimov, 2020).

5.4 Non-verbal Interaction\Physical World

Put extremely simply, this quadrant is an automatic barrier that must be lifted when a computer recognizes a person's face by using a camera. Everything becomes much more complicated when it is necessary to imitate the actions of a person, or a robot must move freely around an apartment or a hospital corridor, send parcels to people and receive objects from them. The virtual space created by people has quantifiable, programmable characteristics, and is very limited in terms of its varieties. Contrasted with it, the reality is inexhaustible. In the physical world, the role of chance increases sharply, and abstraction becomes a separate task (Richert et al, 2018). This quadrant of Turing-like tests is the most challenging because the action in it is directly dependant on the combination of powerful artificial intelligence and advanced robotics. Researchers have simply been ignoring this area since the 40s of the last century, and A. Turing himself set an example. In the meantime, its significance for communication between people is self-evident (for example, gestures) and is emphasized by all researchers of communication. One of the potential tests for this level of robotics development implies the necessity to compare an android and a person: the machine pronounces only the phrases of a person that were previously recorded, but with the maximum resemblance to the person (Ishiguro, 2007).

Also, to determine the intellectual abilities of a machine, one can use the Brooks test (Brooks, 2018) or the E. LENA test, which are based on non-verbal interaction. The Brooks test, probably the hardest to implement in this context, engages all four areas/quadrants of the Turing-like tests.

Examples of artificial intelligence that cope with non-verbal tasks include already existing systems capable of playing computer games, or a virtual TV presenter Elena (created at the Sberbank Robotics Laboratory, she can fully imitate a real TV presenter, her movements, emotions, and gestures). However, both systems do not go beyond the limits of the virtual world. Real interaction with humans in the physical world is still an extremely difficult task. This is not enough for a general artificial intelligence to come true, as such a machine must cover all four areas of interactions and environments (Efimov, 2020).

6. THE ADVENT OF “TECHNO-UMWELTS”

Back in the 19th century, the eminent biologist Jakob Johann von Uexküll noticed that different living creatures had perceptual worlds that were different from those of other species, and peculiar to their one. He called them “umwelts.” By analogy, we propose to call the four areas of a possible machine interaction - “techno-umwelts.” Techno-Umwelt is a domain of world perception, the way a machine sees the world around it. Everyone knows what the personal umwelt is, and many have seen the "techno-umwelt" of unmanned vehicles using radars and lidars in videos (Efimov, 2020).

It seems acceptable to draw a parallel between the post-Turing architecture of an intelligent robot with biological evolution, where an environment (an umwelt) played a key role in the adaptation of biological species. Let us try to compare one of the techno-umwelts to the area where life appeared on Earth – the World Ocean. In this case, the emergence of intelligent robots from the first techno-umwelt can give them new, adaptive features, just as the “blind watchmaker” of evolution has been giving new opportunities for millions of years to living creatures that would come onto land from the ocean. A transition to the next techno-umwelt for robots could mean an upgrade to the next range of features. The point is not that a robot that must autonomously move on land suddenly learns how to swim autonomously. The point is that the capabilities of a robot that has been successful in one of the techno-umwelts should be gradually transferred, like skills, to another techno-umwelt. At the same time, in the evolutionary cycle of the development of intelligent, embodied robots, the role of a human creator is increasing, who can endow robots with additional technical capabilities, while observing the course of their evolution.

The above profile of human-machine interactions (verbal-non-verbal and virtual-physical) give four independent “techno-umwelts”: verbal virtual, non-verbal virtual, verbal, and non-verbal physical. The versatility of Artificial General Intelligence (AGI) is only possible when a machine is capable of shifting freely between all four “techno-umwelts.” The current generation of AI is capable of recognizing objects of different classes without prior training. This is the most important achievement, but it has nothing to do with the capability of working in different “techno-umwelts.” To achieve the latter, it will be required to implement a kind of "translators" from the language inherent to one perceptual world to the language of another. Only then will artificial intelligence be able to become truly multimodal, be able to solve a whole range of potential tasks, and establish a fully-fledged “communication” with a person.

There are many ideas for AGI implementation, like virtual personal assistants, solving different kinds of puzzles or playing board games, and so on. However, none of them are going to be representative of true AGI, as they are limited to just one techno-umwelt, thus rendering their experience from a particular techno-umwelt useless for another one. For example, do not ask an AGI-enabled virtual personal e-mail manager to control a self-driving car. It has no capabilities. However, almost every adult human can drive a car and answer emails (better do not do both at the same time). Humans have an innate ability to act in different environments: we are better than machines in the physical world, but we are struggling to compete with machines in the virtual world, as it is not something inherent to us.

7. CONCLUSIONS: NEW COGNITIVE ARCHITECTURES

The post-Turing approach to AGI methodology allows us to design novel architectures for cognitive systems. For example, instead of separated, silo-like intelligent machines, working in a sense-think-act paradigm in various environments, we could build architectures universal for all techno-umwelts. Of course, we need a low-level integration to fuse robot's skills acquired in various techno-umwelts. Techno codes, translating experiences from one techno-umwelt into another to be used by a robot or a machine, might be a basis for such integration. It resembles the case when the same machine can drive as well as answer emails for its owner.

To summarize, the authors have proposed two things. Firstly, we need to join together the subject, the object, and the observation tool in one unified testbed. Thus, the Turing test will be transformed into a post-Turing one. There is no need for a wall separating the subject and the object – this will only make things worse, creating competition between humans and machines. Future AGI tests should seek better performance of robots and humans working without any "walls", be open to all sorts of interactions, including verbal, non-verbal, virtual and physical.

Secondly, we need to focus our efforts on designing and building machines capable of operating autonomously in various techno-umwelts rather than just manipulating in one at a time. The same robot (or AGI) should be able to autonomously answer questions and drive a car. A specialization profile is for insects and old machines, but not for humans or AGI-enabled robots of the future.

The emergence of AGI will forever change our interactions with technology. After millennia of philosophical reflection and scientific and technological progress, for the first time in history, people will encounter some truly "smart" things, the devices that can possess even more comprehensive and accurate knowledge about the world and us than we do. This situation requires a fresh look at what a person and his mind are to reconsider many well-established concepts. These processes have already begun today, and we are beginning to "dissolve" in the technologies and gadgets that surround us from everywhere. The very notion of "man" is being blurred. As computers master new areas of activity, be it chess or translation, these areas can no longer be considered an exclusive prerogative of a person. Perhaps being a person is something that a machine is not yet capable of imitating. However, human engineers can create a machine that can autonomously get from point A to point B, but one has to be a philosopher to see the place where the point B is situated.

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