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Survey of some Tendencies of Deep Learning

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The paper reports on the basic innovations in the field of deep learning methodology, which can have a significant impact on the development of this field. Modern scientific literature dedicated to the issues of development of areas of use of methodology and certain theoretical approaches are analyzed. The assumptions are presented on the future tendencies of the development of deep learning as a field of scientific applied knowledge and particularly promising directions are studied in critical aspect. The study shows how some unpopular approaches have become the most applied tool in a twinkling of an eye thanks to the sudden explosions of achievements. It is assumed, that this tendency will continue in the next decade. This means that, the popularity of some deep learning methods will plunge and in return new approaches will emerge or methods from the past thought out in a new manner will turn up suddenly. But today, researchers have no answer which approaches will have to dominate and this is the subject of heated discussion. *© 2022 Bull. Georg. Natl. Acad. Sci.*

deep learning, convolutional neural network, capsule neural network, deep self-supervised learning, a hybrid model

The human race – is the race of inventors. The universe offers raw materials, and as we skillfully own craft and are practiced in it, are trying to transform this universe. The technologies created countless set of instruments and equipment: wheel, printing press, steam engine, telescope, microscope, x-ray machine, tomography, automobile, railway, electricity, internet... These inventions have formed and still form our civilization and culture. At the same time, deep learning dominates in artificial intelligence, but it needs to be updated in order to maintain its hegemony and bring its field of science to a new level. Consequently, getting to know the new tendencies, which have just taken definite shape in deep learning should be interesting.

One of the latest creations of technology-is an artificial intelligence, an instrument that has been closely linked to our lives in recent decade. It has a huge impact on society that, as expected, continues to grow within the next few years [1]. Andrew Ng - one of the leading scientists in the field of artificial intelligence went so far that even drew the following parallels: artificial Intelligence – is a new electricity [2].

In an interview with Stanford Graduate School of Business, he stated: “Just as electricity transformed almost everything 100 years ago,

today I actually have a hard time thinking of an industry that I do not think AI will transform in the next several years".

But artificial intelligence is not novelty. It has existed since 1956, when John McCarthy coined the term and proposed that artificial intelligence be considered an independent field of research [3]. Since that time, artificial intelligence has gone through periods of uncovered indifference, as well as generous funding and increased interest [4], which interchanged with each other.

Today, machine learning and deep learning have monopolized artificial intelligence. The deep learning revolution that began in 2012 is not over yet. Deep learning is in the lead in the field of artificial intelligence, but experts share the common view that some changes will be required to maintain this leadership. It is interesting to see what awaits deep learning in the near future.

Release from Convolutional Neural Networks

The popularity of deep learning has increased sharply, since Geoffrey Hinton, the "Godfather of Artificial Intelligence" and his team won the Image Net competition in 2012 with a model built on Convolutional Neural Net (CNN). They destroyed their competitors who had not used deep learning [4], and received (+10%) tolerance 63,30% (-1%) when achieving accuracy. We can say, that we should thank CNN Convolutional networks for their success and interest, which has accompanied deep learning over the last decade.

The models built on convolutional networks have become very popular in computer vision tasks which refer to images [5], objects, or identification of persons. And, despite their success, Geoffrey Hinton, in one of his last key speeches at the AAAI 2020 conference (AAAI, Association for the Advancement of Artificial Intelligence), points out one major drawback, gap: "[Convolutional networks] cannot handle very well with the results caused by changes of viewpoints, for example, while rotation and scaling".

Convolutional networks can process transmissions, but the human visual system also has the ability to identify objects with different angles of view, on different backgrounds and different lighting, which convolutional networks cannot.

While the best-ever convolutional network (which achieves + 90% accuracy in the Image Net reference test) tries to classify images into a collection of data of real objects, its efficiency is decreased by 40-45 percent.

The second problem concerns the so-called *Competing Examples*. Hinton goes back again and emphasizes the difference between the human vision system and the convolutional network: "I can take an image with a not-so-great level of noise, and this is perceived by the convolutional network as something completely different, while I, I doubt, to notice a change in the object. I consider this to be evidence that convolutional networks actually do not use the information we rely on in order to identify images". Convolutional networks are fundamentally different from the human vision system. We just cannot trust these networks because of their unpredictability.

Hinton goes even further and explains that systems built on convolutional neural networks are unable to interpret those objects, which they see in images. We know from a very young age, that there are objects in the universe and we have the experience of interacting with them. We have heard since childhood about the strength, thickness, constancy or flowability of shape. We can use this knowledge to find out about these amazing objects, but convolutional networks see only a pile of pixels. We may even have to radically change the place of prevailing paradigm of computer vision, displace it, it is expected, towards capsule networks.

Capsule Neural Network (Caps Net) – is an architecture of artificial neural networks, which is designed to identify images.

The main advantages of this architecture are the substantial reduction in the volume of selected needed to learn, as well as the increase in detection accuracy and resistance to "white box" type attacks when the malefactor has data on the algorithm. A key innovation in capsule networks is the existence of so-called capsules – elements that are intermediate units between neurons and layers. These elements represent groups of virtual neurons that observe not only individual details (small things) of an image, but also their disposition towards each other. This architecture was though up by Jeffrey Hinton in 1979. It was formed in 2011 and published in October 2017 in two articles.

According to “Father of Quantum Mechanics”, Max Planck: “Science progresses one funeral at a time”.

Deep Self-Supervised Learning

One of the pioneers of deep learning Yann LeCun states, says that supervised learning – the method of learning greater systems built on deep learning – should be replaced by what, he calls *self-supervised learning*) [6]:

“[Self-supervised learning] – It is an idea, which lies in learning to imagine the universe before studying a task. This is exactly what children and animals do. After receiving a good (in-depth) idea of the universe, studying the task requires a few samples and a few selections”.

Instead of conducting the teaching on the marked (notched) data, the system will learn on the raw data to mark it itself. We humans learn faster to some extent, than systems encouraged (consolidated) or controlled by machine learning.

In December 2019, Yann LeCun delivered a very interesting report [7] on this topic. He proved that the self-supervised system would be able to "Predict any part of the data incoming from any other part". For example, it would be able to predict the future with the past or the hidden - with the help of the visible. But, despite that, this type of learning works well for discrete input variables such as text (Google BERT or Open AI GPT-3), it does not work well for continuous data too, such as, say, images, audio or video. To do this, he noted, we will need latent (covert) models based on variable energies that are better suited to the uncertainty characteristic to the universe.

Independent learning will defeat supervised learning. There are still some problems ahead, but a bridge is already being built to overcome the split. We can say for sure, that we will not have to look back when we turn out to be the other side.

Hybrid Models

Two paradigms in the field of artificial intelligence have gained unprecedented popularity since its conception. These are: symbolic artificial intelligence (otherwise, rule-based artificial intelligence) and deep (in-depth) learning. Symbolic artificial intelligence dominated in this field from the 1950s to the 1980s, but today most experts oppose this system of beliefs. John Haugeland called it symbolic artificial intelligence in his book “Artificial Intelligence: The Very Idea” [8].

“[Symbolic artificial intelligence]” works with abstract representations of the real world and is modeled through representative languages that rely primarily on mathematical logic".

This approach to artificial intelligence is aimed at giving the machine intelligence using a "high-level symbolic representation of problems". Herewith, it is in complete agreement with the hypothesis of a physical system of symbols formulated by Allen Newell and Herbert A. Simon [9]. For example, expert systems [10] – the most popular form of symbolic artificial intelligence – were created to imitate human decision-making and according to a set of "if-then" rules.

Hybrid models – this is an attempt to combine the advantages of symbolic artificial intelligence and deep learning. In the book «Architects of Intelligence» [11] Martin Ford interviewed the experts of artificial intelligence about this approach. For example, Andrew Ng emphasizes its usefulness in

solving problems when we have only extracts of small volumes of data. Josh Tenenbaum, Professor of Computational Cognitive Science at the Massachusetts Institute of technology, together with his team, created a hybrid model, “which studies the visual concepts, words, and semantic analysis of sentences without any obvious control over them”.

Gary Marcus, a professor of psychology at New York University, proves that discussions based on common sense and reasonableness would be better suited to hybrid models. In one of his recent articles [12], Marcus emphasizes his point of view and even cites the human mind in support:

“Symbolic processing seems to have in some way essential meaning to a person’s cognitive talent (giftedness, ability). For example, when a child understands the meaning of a concept such as brother, this word can be used in an infinite number of families”.

Despite a promising future, the hybrid approach also has significant critics. Geoffrey Hinton criticizes those who intend to spoil (ruin) deep learning with symbolic artificial intelligence. "They need to recognize that deep learning is a stunning (amazing, surprising, astonishing) thing, and they want to use it as a kind of low-level servant, that would give them everything they need to make their symbolic reasoning work," he states. Regardless of whether this decision works, hybrid models need to be monitored within the next few years.

Secondly, Gary Marcus, a Professor of Psychology at New-York University states: – “I think that in just a few years, a lot of people will be interested, “Why did he/she try not to turn to artificial intelligence for such a long time, mainly for impressive priceless tools for character processing?”

Conclusion

Deep learning systems are very useful. In recent years, they have – completely alone- changed the technological landscape. But, if we want to create truly intelligent machines, deep learning will need to be qualitatively upgraded – to refuse to the principle "the more the better".

There are several ways to reach this important landmark today:

Rescuing from Convolutional Neural Networks and from the constraints characterizing them;

B) Releasing from marked (notched) data;

C) Combining from below to upwards processing with top-down processing;

D) Equipping the computer with the cognitive capabilities of System 2;

E) And finally, the realization of ideas and achievements of the study of neurobiology and the study of the human brain in computer practice.

It is interesting to compare this list with the approximate chronology of the achievements of artificial intelligence for the first half of the twenty-first century. This chronology was formed as follows:

2000 – Symbiosis between human and computer;

2000 – Highways with automatic control of vehicles;

2025 – Avoiding the action of the aging mechanism, the "immortality" of humans;

2045 – Automatic reading of the thought.

Artificial intelligence catches up a human more and more rapidly and steps on his/her feet, but in order to develop, artificial intelligence requires the efforts of many people in different fields of knowledge.

ინფორმატიკა

მანქანური სწავლების (ღრმა სწავლების) ზოგიერთი ტენდენციის მიმოხილვა

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**აკადემიის წევრი, საქართველოს ტექნიკური უნივერსიტეტი, ინფორმატიკისა და მართვის სისტემების ფაკულტეტი, თბილისი, საქართველო*
***საქართველოს ტექნიკური უნივერსიტეტი, ინფორმატიკისა და მართვის სისტემების ფაკულტეტი, თბილისი, საქართველო*

სტატიაში განხილულია ღრმა სწავლების მეთოდოლოგიის სფეროს ძირითადი ნოვაციები, რომლებსაც შეუძლია მნიშვნელოვანი გავლენის მოხდენა მოცემული დარგის განვითარებაზე. გაანალიზებულია მეთოდოლოგიისა და გარკვეული თეორიული მიდგომების გამოყენების სფეროთა განვითარების საკითხებისადმი მიძღვნილი თანამედროვე სამეცნიერო ლიტერატურა. ჩამოყალიბებულია ვარაუდები ღრმა სწავლების – როგორც სამეცნიერო-გამოყენებითი ცოდნის სფეროს – განვითარების მომავალ ტენდენციებზე და კრიტიკულ ასპექტში შესწავლილია განსაკუთრებით პერსპექტიული მიმართულებები. ჩატარებული კვლევა გვიჩვენებს, როგორ გახდა ზოგიერთი არაპოპულარული მიდგომა ყველაზე გამოყენებითი ინსტრუმენტი მიღწევათა უეცარი აფეთქებების წყალობით. ვარაუდია, რომ მომავალ ათწლეულში ეს ტენდენცია გაგრძელდება. ეს კი იმას ნიშნავს, რომ ღრმა სწავლების ზოგიერთი მეთოდის პოპულარობა დაეცემა და სანაცვლოდ გაჩნდება ახალი მიდგომები ან ამოტივტივდება ახლებურად გააზრებული მეთოდები წარსულიდან. მაგრამ დღეს მკვლევარებს არ აქვთ პასუხი იმაზე, თუ კონკრეტულად რომელ მიდგომებს მოუწევს გაბატონება და ეს საკითხი ცხარე კამათის საგანია.

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