The future of robotic movement in virtual environment: Efficacy and profitability

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Abstract. One of the main goals of humanity is to move further with each generation and introduce new ways for comfort and development. At the moment, we have reached a level that was a fantasy a few centuries ago. New devices and technologies are introduced constantly, and most of them decay before reaching the market or the user. A new era of technological revolution is near, and therefore, we must be ready with the technology we have now. This article aims to illustrate that some technology can be used to prepare us for the future. By utilizing available technology to test and virtually advance emerging technologies, we can make their transition and establishment easier.

1 Introduction

One of the main advantages of the modern day is the availability of technology. Most of the routine work can be handled by technology. It is well embedded in our daily life that the absence of it can have a dramatic influence on the users. Different industries greatly utilize modern technology. The use of it can positively affect production rates and profitability. There is always new technology in the market that will outperform the existing ones. In other words, technology is so well integrated in our lives that it is hard to imagine a normal life without it.

It is well known that humans use technology and can benefit from it, but what about other technologies? Other technologies can definitely be used to push the limits of different types of technologies. Sometimes they complement each other. Other times, one can be used to steadily activate others. For instance, engineering software can be used to build and test technology that is yet to be created. In this way, one technology can push the creation of another technology a bit further, making it more convenient. After simulations and amendments, new technology can be established. However, it is not always that simple. Sometimes, visualized and theoretically working technology cannot be recreated in the real world as there are some limitations to what we can achieve.

One of the limitations, and the main topic of this work, is advanced mechanical robotics. We as humans have gotten far with robotics, but there are still limits to overcome. There are many mechanisms that are greatly used in day-to-day activities and in complex industrial

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processes. These mechanisms or robotics are well defined in what they can do and how precise they are. However, human-like robots are still in the future as we lack some technological breakthroughs. Nonetheless, we can prepare virtually and theoretically for this future of robotics using the technology we have at hand. The following article will go through the use of different technological tools that can prepare us for future technology [1, 2, 3].

2 Present and future robotics

2.1 Modern robotics

The most commonly used robot-like technology is mechanical arms. They are greatly utilized in different industries. The use of these mechanical arms has not been a novelty for the past few decades. But with progress in programming complex algorithms, their capability and precision are steadily improving. The motion of some robotic arms imitates human joints, but most of the time the mechanisms differ due to the tasks and environment. Some robotic arms have extra joints and the ability to extend if necessary. Such mechanisms are called redundant due to the large number of degrees of freedom. However, lately, fully human-like robots are flashing on different platforms, claiming that they move in various environments with confidence. However, there are many challenges to overcome. First of all, the weight of the structure, movement limitations, battery capacity, and many more factors. The major issue is related to their capability to interact with complex environments. It is true that they can do complex tasks and movements, but they all take place in an ideal environment. In reality, environmental conditions are most of the time unknown and hence unpredictable [4, 5].

2.2 Anticipating robotics

It is anticipated that in the next few decades, robots will walk freely among humans. Therefore, they must adapt to different changes. The main limitation of robotics, which is flexibility and functionality, will be eliminated. However, they cannot be immediately released to the public for their knowledge accumulation. Yes, they will be learning from interaction and sharing data to accumulate knowledge. However, it is dangerous to gather data through interaction in the real world as it may introduce different challenges. Therefore, with modern technology, they must be taught to learn [6].

3 Virtual Reality and Robotic Learning

The first thing that comes to mind when dealing with virtual reality and robotic learning is simulation-based training. This is a revolutionary method that can be used to train robots in a safe and unlimited world where most possible scenarios are run before deploying these robots into the real world. This method allows researchers to use different obstacles and complex environments to accumulate the necessary skills and knowledge in a safe environment.

3.1 The use of software packages

First of all, software packages are used to build a replica of the real-world environment in the most detailed manner possible. At this stage, different engineering software can be utilized for modeling the environment. However, even with the most advanced tools, absolute similarity is unattainable. Nonetheless, it can be used as the main source of knowledge accumulation, which will suit modern standards. These virtual spaces can consist of real-world physics engines that can simulate realistic dynamics, such as gravity, friction, collisions, and so on. The environment can be as simple as possible with little interaction and obstacles, or it can be as complex as the real world with unpredictable elements [7].

3.2 Artificial intelligence embedment

The second task is relatively complex compared to environment modeling. With the robotic mechanisms ready in the built reality, they must be given some kind of thinking element. In this case, it is artificial intelligence, or in other words, complex algorithms. These mechanisms are embedded with machine learning algorithms, such as reinforcement learning, for acquiring knowledge through mistakes and trials. The idea of reinforcement learning is to give feedback in the form of penalties and rewards. For example, if a robot in action successfully avoids an obstacle, it will be rewarded, and if it collides with an object, it will be penalized. Therefore, throughout the journey in the built environment with different elements, these robots will learn and accumulate knowledge for the successful completion of the path from position one to the end [8, 9].

3.3 Data analysis and generation

After running a simulation on a certain task, data will be generated. In a large-scale simulation, massive amounts of data will be gathered. It is also true that one task can be done millions of times, thus increasing the capabilities of robotics and the data generated. In the real world, it is hard to imagine running the same task that many times. This would require a long period of time and significant resources.

3.4 Various platforms for simulation

There are different platforms that allow researchers to simulate the necessary tasks in different environments. The following are common platforms for simulations: OpenAI's Gym, NVIDIA Isaac Sim, Unity’s ML-Agents, and DeepMind's MuJoCo. These are specifically built for the aforementioned purposes. These platforms have various environments where robots can practice tasks such as navigation, object manipulation, movement, and so on. [10].

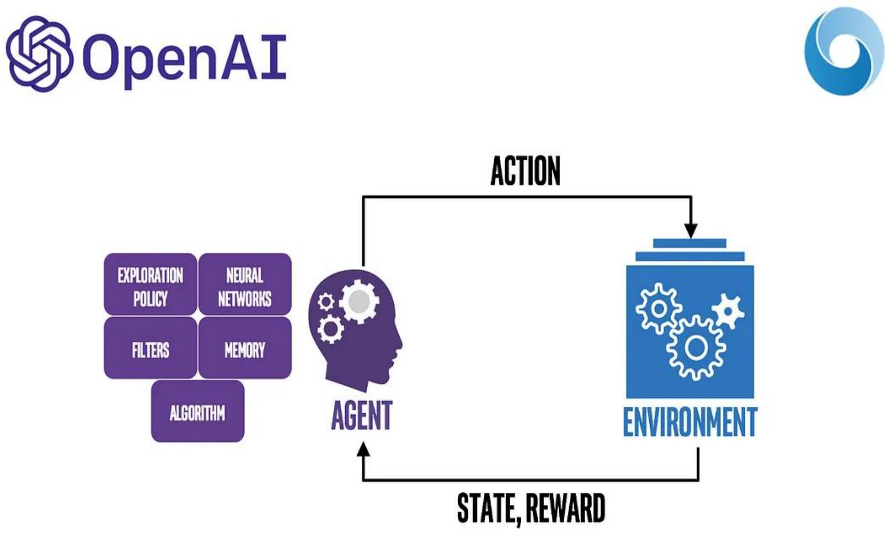

Fig. 1. OpenAI'S Gym and reinforcement learning

4 Advantages of the Use of Virtual Realities

There are a number of advantages to utilizing such tools or platforms. The most obvious reason for robots to learn in virtual reality is cost. Since everything is conducted in virtual reality, there is no need for real resources such as premises, apparatus, furniture, obstacles, and so on. The list of resources that would be used if tests were done in real life would go on. There is not just one test, but thousands of different tests. Therefore, repair costs and maintenance costs would greatly affect the overall cost as well.

The second, and also one of the main aspects when performing any test, is the safety of personnel and the environment. As is obvious, there is no real human presence or environment in virtual reality, and hence, no safety issues would arise. In reality, personnel safety must be strictly managed. With safety concerns, the testing would be postponed indefinitely or eliminated completely. However, it is fair to say that no human nor environment will be in danger of safety issues in virtual reality. Still, safety must be included in tests as they will eventually transition to reality. That is why it is significant to understand the technology and its capabilities in depth.

The next advantage is the scalability of conducting simulations. In real life, tests are performed in a small area designated only for certain tasks and outcomes. In virtual reality, the scale of the working (testing) area can be extended infinitely. Of course, it all comes down to the capability of the computing machine, but beyond that, the limits are in the hands of researchers. With the help of artificial intelligence, the environment can be extended with diverse elements for the robots to interact with. Similar to scale, the speed is also under the control of the researcher. In reality, time cannot be accelerated to speed up tests. In a controlled environment, however, the speed can be increased.

Another advantage is the control of different variables. Virtual reality can be controlled in many aspects. For instance, the environment can be changed in a short period of time or in just a second. Similarly, all the elements in the environment can be easily manipulated. [11, 12, 13].

5 Conclusion

Technological progress is penetrating all industries and sectors, yet there are some fields that still need improvement. With the advancement of artificial intelligence and mechanics, we are able to build complex mechanisms for various tasks. However, we are still far from building a human-like robot that can perform similar tasks. Nonetheless, there are different tools and methods that can be used to accelerate this progress. Therefore, this work focuses on virtual reality for robotic improvement. The following work discusses different methods used to safely test the capabilities of robotics and, hence, accumulate the necessary knowledge.

References

1. I. A. Magomedov, Z. A. Dzhabrailov and A. A. Elmurzaev, *Key steps for performing numerical analysis utilizing modern software tools,* Journal of Physics: Conference Series, 1889, (2021)
2. A. N. Khusnutdinov, & M. G. Nuriev*, The Sound Pressure Level Meter,* International Russian Automation Conference (RusAutoCon). pp. 63-68 (2022)
3. J. Allen and P. Kouppas, Computer Aided Design: Past, Present, Future Design and Designing: A Critical Introduction. pp. 97-111 (2012)
4. I. Magomedov, M. Matygov, & Z. Dzhabrailov, *Mechatronics: Development and Improvement of the Existing Robotic Arm 7 Degree of Freedom*. In P. Stanimorovic, A. A. Stupina, E. Semenkin, & I. V. Kovalev (Eds.), Hybrid Methods of Modeling and Optimization in Complex Systems, vol 1. European Proceedings of Computers and Technology, pp. 264-269, (2023)
5. K. M. Lynch and F. C. Park, Modern Robotics: Mechanics, Planning, and Control (2017)
6. L. Matt, Mastering SolidWorks. (John Wiley & Sons). pp.13-57 (2018)
7. C. McClintock, A Beginner's Guide to Generative Design, PTC, (2023)
8. I. Magomedov, E. Belashova, M-D. Bersanov, Review article: enhancing the power of artificial intelligence in mechanical design, E3S Web of Conferences. VOL. 402, 03042 (2023)
9. A. K. Rakhmatullin & R. F. Gibadullin, Lobachevskii Journal of Mathematics, vol. 43(2), pp. 473-483. (2022)
10. J. Arroyo, C. Manna, F. Spiessens, L. Helsen and K.U. Leuven, *An OpenAI-Gym environment for the Building Optimization Testing (BOPTEST) framework*. Heverlee, Belgium (2021)
11. H.-M. Huang, S.-S. Liaw, and C.-M. Lai, "Exploring learner acceptance of the use of virtual reality in medical education: a case study of desktop and projectionbased display systems," Interactive Learning Environments, no. ahead-of-print, pp. 1–17, (2013).
12. Z. Merchant, E. T. Goetz, L. Cifuentes, W. KeeneyKennicutt, and T. J. Davis, "Effectiveness of virtual reality-based instruction on students' learning outcomes in k-12 and higher education: A metaanalysis," Computers & Education, vol. 70, pp. 29–40, (2014).
13. A. Abulrub, A. N. Attridge, and M. A. Williams, "Virtual reality in engineering education: The future of creative learning," in Global Engineering Education Conference (EDUCON), 2011 IEEE. IEEE, 2011, pp. 751–757. (2011)