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Challenges and Future of AI driven Robochemist

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Abstract

The rise of Artificial Intelligence (AI) integrated robots is a major shift fundamentally in the material and chemical research field enabling the development of autonomous laboratories driven with high efficiency, work perfection, minimum time requirement and minimum human interface. The opportunities, challenges and future of AI robots have been discussed in detail providing an overview of the technical, ethical and cultural shift required to support the paradigm. A much collaborative approach where human intelligence and AI intelligence co-create knowledge providing much higher level of strength. Chemical synthesis automation is a present day need for accelerating the pace of discovery and synthesizing novel compounds in pharmaceutical, material science and other applications. The present work focuses on the technologies, applications and challenges these automation and AI integration of robots faces and the responsibility that accompany the development of robochemist. Despite various advancements, identification and designing of synthetic robots is still a manual process and require manually configured experimental synthesis to suit the type of chemist which still require time and efforts for expert chemists. Automated chemical synthesis provides reliable solution and repeated access to large compound laboratories for screening, providing safer, efficient and reproducibility for both research and industry laboratories.

Keywords: Robochemist, Automated, Chemical Laboratories

Introduction

Robots are now a days finding increased applications in the field of health care, industries and service sectors. In chemical industries robots find very beneficial role where repetitive action is required for example mixing, heating, filtering and weighing acids or toxic ingredients. Repetitive and dull manufacturing tasks can very easily be performed by robots. They can be used in any environmental conditions which is otherwise not suitable for human survival, and can handle hazardous chemicals which most chemical factories faces making the industrial processing very easy. Industries are now increasingly using robots for production, assembly, handling, packaging and even palletizing resulting in better production, quality, accuracy and speed than humans workers could have achieved.

Reasons to use robots in chemical industries

1. Easy handling of toxic chemicals and materials
2. Handling of hazardous material operations eg. Nuclear materials
3. Cleaner and safer environment- reduce dust and pollutants and remove work related accidents
4. Clean room working
5. Elevate precision

Robots can find much application in laboratory exercises as well for eg. in filtration, extraction etc(1). Robots are trained to access systems, modify analytical procedures within established limits in order to restore analytical capability and maintain production (1).Pharmaceutical companies employ robots to move chemicals samples to synthesize novel chemical entities or to test pharmaceutical value of existing entities chemical

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matter (1),(2). Advanced lab robotics can be used to completely automate the process of science as in the Robot Science Project.

Robots are helping in chemical movement in synthesizing novel chemical entities in pharmaceutical companies as well as employed for testing pharmaceutical values of existing chemical matters. Several robots are already in use in various fields of chemistry. Water analysis employs low cost robotics which give much better performance as compared to the most expensive auto samplers. In July 2020 scientists reported new mobile robot chemists which work nearly around the clock automatically make decision on his next action on experimental results.

With increased functionality of robotics and increased applications in chemistry exercises much more advanced robots are required to be prepared. Robots and AI are two distinct fields with different methodologies and objectives. Physical aspect of designing machines, building hardware to perform specific tasks are the main objectives of robots. However, AI on the other hand is the brain of intelligent system AI involves software capable of learning and making decisions hence called the brain of intelligent systems.

Robot and AI when joined together blends the physical capabilities with intelligence. AI equipped robots can analyze data, adapt to new scenarios and perform task with precision. Robots are now much smarter, understanding machine language, more flexible and autonomous.

Here are the key ways in which AI is used in robotics today:

1. Machine learning: By incorporating AI in robots, robots can learn from experience and can improve with time.
2. Natural language Processing (NLP): In order to interpret human language robots are equipped with NLP. Humanoid robots and customer service robots used in retail and health care services can be beneficial with this.
3. Computer Vision: In order to convert visual data to tasks eg. Object recognition, quality control, and navigation AI helps robots. This technology is helpful in autonomous vehicles.
4. Edge Computing: In autonomous manufacturing robots, AI powered robots used edge computing to process sensor data locally in real time, enabling fast decisions.
5. Conversational AI: In customer services robots and companionship robots AI helps robots to stimulate human like interactions.

AI can be used to revolutionize robotic chemistry by integrating with robotic systems. AI has brought great revolution in the field of chemistry by creating much advanced robots. Concept of robot chemists with AI driven advancement technologies emerges in 2010s where AI act as a brain and robot being the physical body enabling easy handling of chemicals and enhancing autonomous research.. Robots can be beneficial in pharmaceutical chemistry where challenges persists in the synthesis of organic molecules using universal synthetic platform (3),(4). In reach for an intelligent mode for complex organic molecule synthesis AI driven robotic chemist is capable of autonomous task from synthetic pathway planning to conducting experiments in batch reactors.

Robots already in use:

1. Robochem (University of Amsterdam):- To accelerate chemical discovery the autonomous bench top platform uses an integrated AI unit and machine learning. It is specialized in flow chemistry where

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synthesis is carried out in a system of tubes reducing waste and time. In test Robochem can synthesize in single week rather than months required by human workers.

2. Mobile AI powered robots (University of Liverpool) - This robot was 1.75m tall using AI to make its own decisions. This robot can move in lab intelligently. It can decide the next step in chemical reactions, performs experiments, collect the data, analyze the result and perform task as par with humans but in much smaller time.
3. Synbot (Kaist, South Korea) – This autonomous robot operates in a self contained lab with modules for dispensing reactions and analysis. It integrates AI for planning synthesis and carrying out reactions with optimal yields.
4. Material design with Google AI: At university of Glosgow partnered with Google AI developed a robotic chemistry laboratory for synthesis of new inorganic materials.

Impact on Chemical Research

1. Increase pace of discovery:- The use of automated robots working 24/7 can achieve a process that normally takes months in just few days.
2. Increased accuracy and Reproducibility :- Robots performed work in a much systematic and with consistency bringing accuracy and more dependable data (5).
3. Cost and Resource Efficiency :- By optimizing reactions, the waste reduction and use of expensive materials can be achieved important in drug and material discovery.
4. Safer Laboratories :- Robots can handle dangerous experiments involving hazardous chemicals without affecting human lives keeping humans at a safe distance.(6).

The convergence of robots and AI Make a shift from rigid automation towards adaptive, much intelligent and collaborative systems. These robots can act as a genuine partner for discovery process. Rather than replacing chemists, robochemist assist them in completing challenges and accelerating the more complex problems.

However we are still far from reaching full autonomy. No single strategy can execute full spectrum of chemical manipulations. In this transition states, a crucial complement is achieved by teleoperation (7). It enables chemist to operate robots from a distance maintaining fine control over delicate procedures. Teleoperation channel can function as human in loop interface (8) allowing the operators to help when robot encounters errors.

Challenges and Opportunities

Although vision of fully automated robotic laboratory is compelling, but reaching the goal has many hurdles. Several key challenges need to be addressed to fully address the potential of robochemists. Various hurdles under these line includes-

1. Absence of proper modular hardware and software.
2. Another challenge lies in manipulation of robotic systems.
3. System Customization:- Extensive customization including the choice of robotic architecture, material selection, sensor integration and software development for precise control.
4. Programming for creativity :- The challenge is to give AI more creative agency to reduce human oversight.

Conclusion

The rise of AI incorporated robochemists is a futuristic step towards laboratory automation and transformation in the strategy of chemical discovery tactics. A much flexible environment is provided to laboratory showing vast versatility in handling experimental tasks with varying complexity levels. Tedious repetitive tasks in chemical manufacturing industries can be achieved with greater efficiency innovation and sustainability. Such development will not substitute human chemists but rather assist them in enhancing creativity and judgment by adding exactness, repeatability and stamina. The drive toward a more reliable, practical research trajectory.

References-

(1). Ward, K.B.; Perozzo, M.A.; Zuk, W.M. "Automatic preparation of protein crystals using laboratory robotics and automated visual inspection" Journal of Crystal growth. 1988, 90(1-3), 325-339.

(2). Mortimer, James A, Hurst, W. Jeffery. Laboratory robotics: a guide to planning, programming and applications. New York, N.Y., VCH Publishers, 1987.

(3). Coley,C.W., Eyke, N.S, Jensen,K.F., Autonomous discovery in the chemical sciences. Part I: Progress. Angew. Chem. Int. Ed. Engl, 2020, 59, 22853-22893,

(4). Coley,W., Eyke,N.S., Jensen,K.F., Autonomous discovery in the chemical sciences. Part II: Outlook. Angew. Chem. Int. Ed. Engl, 2020, 59, 23414-23436.

(5). Kearnes, S.M., Maser, M.R., Wleklinski, M., Kast, A., Doyle, A.G., Dreher, S.D., Hawkins,J.M., Jensen,K.F., and Coley,C.W., " The open reaction database Journal of American Chemical Society, Vol, 143, no.45, 2021,pp.18820-18826,

(6). Omair, A.O.M., Jabber, A.M.A., and Albulushi, M.O., " Recent advancements in laboratory automation technology and their impact on scientific research and laboratory procedures" International Journal of health Sciences, 2023,Vol 7, no.S1, pp.3043-3052.

(7). Abramson,N., " The aloha System: Another alternatives for computer communications " in Proceedings of the November 17-19, 1970, fall joint computer conference,1970, pp. 281-285.

(8) Wu,P., Shentu,Y., Liao, Q.,Jin,D., Guo,M., Sreenath,K., Lin,X., and Abbeel., P.," Robocopilot: Human-in-the-loop interactive imitation learning for robot manipulation" Arxiv, Vol. abs/ 2503.07771, 20256