OPEN ACCESS
Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 04| Issue 05 | Sept.-Oct. | 2024
Journal homepage: https://gjrpublication.com/gjrecs/
Review Article

The Ups and Downs of Robotic Arms: Navigating the Challenges

*Isa Ali Ibrahim [1], Muhammad Ahmad Baballe [2]

[1]School of Information and Communications Technology, Federal University of Technology Owerri, Imo State, Nigeria.
https://orcid.org/0000-0002-1418-9911
[2]Department of Mechatronics Engineering, Nigerian Defence Academy (NDA), Kaduna, Nigeria.
https://orcid.org/0000-0001-9441-7023

DOI: 10.5281/zenodo.13774819 **Submission Date:** 07 Aug. 2024| **Published Date:** 18 Sept. 2024

***Corresponding author:** Isa Ali Ibrahim
School of Information and Communications Technology, Federal University of Technology Owerri, Imo State, Nigeria.
ORCID: 0000-0002-1418-9911

Abstract
The study explores the impact of Cabot's robotic systems on modern industrial operations, highlighting their precision and user-friendliness. Electronic technology has advanced with recent technological advancements, and the ultimate goal of these technological advancements is to create robotic systems that are as human-like as feasible. Thanks to the blessing of technical advancements, Cabot's will be able to do duties significantly more effectively than humans in difficult or urgent conditions where people are unable to do them. Several studies have been evaluated in this study, and we have seen the effects and difficulties of employing Cabot's over humans as well as the difficulties it encountered.

Keywords: *Challenges, Arduino, Color Sorting, Cabot's Arm; Servo Motor; Shape Detection.*

I. INTRODUCTION
With the recent and continued improvement of science and technology nowadays, human living standards have been enhanced worldwide [19]. It has likewise improved economic growth and life anticipation [15]. Therefore, with such progress, human beings' work habits have changed considerably universally [16]. The use of robots in several fields, such as military combat, industrial production, and many other applications in recent years, has received extensive consideration [1, 20]. To minimize labor costs, production time, and possible dangers in different types of risky tasks, the usage of robots is also encouraged [2]. For example, robotic arms are now often employed in many cases to execute jobs that humans cannot or will not undertake due to the high risk surrounding their environment [17]. Besides, to assist disabled or elderly people, computer vision-based robotic arms have been utilized in recent times [3]. Computer vision is a current improvement in the field of artificial intelligence (AI), and it is widely employed in industrial automation, detection, automated technology, and object identification [21, 22]. Picking and placing products faultlessly with unswerving motions is important in an industrial setting [4]. Additional control systems, such as joysticks or controllers, and even manual programming are now used to maneuver the erudite robotic arm [5]. The robotic system may offer a range of devices (sensors) such as temperature, radiation, color, weight, and so on [23]. Nevertheless, there is a growing propensity to substitute all of these sensors with a single-lens camera and computer vision approaches to perform the responsibilities independently with enhanced precision [24]. In this method, an innovative control method is employed using computer vision to drive a robotic arm [25]. Thanks to artificial intelligence and computer vision methods, a costefficient, user-friendly, and highly efficient robotic arm can be built using such methods [26]. Artificial intelligence and computer vision have been brilliantly used to operate complex robotic systems in a variety of works. For example, in a new work [6], the authors designed an automated robotic arm-based assistance device by employing simple stereo matching and Q-learning optimization methods. This proposed device can perform five degrees of operation in a single instance and detect any object with the aid of stereo vision. The system likewise keeps track of an object's parameters. The stereo camera can recognize RGB color. In this work, the Q-learning framework [29] is employed to control the position of the robot's arm. Lastly, the paper presented experiments to detect an object's stereo vision and feature point. The downfall of this research is that it did not specify the precise distance between the objects. In [7], the authors present

a new approach using a two-armed industrial robot for bimanual hybrid motion/force control and visual serving. This work aims to develop a telerobotic system that can manipulate a grabbed item with both arms. The experimental test bed is a dual-arm industrial robot with fifteen degrees of freedom, a camera, a torque/force sensor, and a rubber contact pad on each wrist. The operator's orders are sent by gestures using a Microsoft Kinect sensor. Seven processes are running on three PCs, and they are connected via a local hub using the protocol called TCP/IP. In addition, this author added global planning approaches to manage local equilibrium and more complex redundancy resolution. In this current research [8] , the authors established a fusion-based manipulation of sensory-motor and a robotic bionic arm, a control strategy for grasping for an automated hand-eye system. This anticipated device was developed through vision serving, motion optimization, and a hybrid force approach. The arm of the robot was designed by joining various motors with an Arduino and was controlled with the aid of a Point Grey Bumblebee stereo camera. The hand was working from a matrix calculation using epee polar geometry [30]. In this research, various types of information like joint, relaxation, and grasping time graphs are collected with the help of 3 finger forces and a 20 frame per second camera capturing the images. In [9], the authors explore the idea of building a robot that can track colored objects. The brightly colored object has a basic design. A wheeled robot has been designed by utilizing a motor and wheels. A Pixy-2-based wheeled robot with sensors is used to distinguish objects with dissimilar colors. This robot moves in the same direction as the thing it's attached to be moving. When it comes to movement, this robot has two wheels, one on each side (right and left). The Arduino microcontroller is in charge of controlling the movement of this robot. In this current research [10], the author designed a self-feeding assistive robotic arm with seven degrees of freedom (DOF) for people with severe incapacities. The system uses a robotic arm simulator to get the motion of the robotic arm. In the process, inverse kinematics equations [31] were used to control the robot's arm position. The research showed that the robot could efficaciously transfer the food to the appropriate location for its user. The author conducted further experiments by adding a web camera that is attached to the end-effector of the robotic arm to monitor whether food dropped from its edge was eaten or not. The research in [11] emphasizes employing a computer vision-based robotic arm that will perceive numerous objects by color sorting, grab that object, and place it in a specific place. The proposed system will likewise measure the width, length, and distance between objects and identify the objects' position with the help of the computer vision method. The arm will do the movement using a servo motor controlled by an Arduino microcontroller as the brain of the whole system.

II. THE CHALLENGES OF ROBOTIC ARMS

1. **Precision in robotic arm operations**
   An essential component of any effective robotic arm operation is precision. In particular industrial operations where precise movements are necessary, inaccurate placement might result in expensive mistakes and harm the company's reputation. Positional errors are a common problem for traditional robotic arms; these errors are mostly caused by belt flex and the requirement for homing at starting.
2. **Fear of power interruptions disrupting operations**
   Power outages in automated operations can be a major source of worry. Sudden stops brought on by power outages not only cause disruptions to operations, but they also put the products and equipment the robotic arm is handling at risk of breaking down. Creating a system that can handle deceleration gracefully in the case of a power outage is the difficult part.
3. **Complexities in setting up robotic arms**
   Robotic arm setup can be very complex, requiring a complex network of wires and connectors. This complexity creates difficulties not just for the first installation but also for later maintenance and troubleshooting. Companies that are new to automation, in particular, look for solutions with an easy-to-use integration approach.
4. **Limited payload capacity in robotic arms**
   Robotic arms' adaptability is largely determined by their payload capacity. The applications of many classic models are limited because they have difficulty managing larger loads. This problem is particularly noticeable in sectors where a variety of jobs call for different levels of strength and accuracy, eventually compromising operational flexibility and efficiency.
5. **Limited connectivity options for robotic arms**
   In industrial applications where robotic arms interface with different tools and equipment, connectivity is an important factor to take into account. The difficulty is in giving a robotic arm enough connection choices to adjust to the various requirements of various activities, such as pneumatic devices and end-of-arm tools.
6. **Threats to electronic components in industrial settings**
   Electronic components may be exposed to unfavorable conditions in industrial settings, thereby compromising their dependability. Therefore, in order to ensure the longevity and reliable operation of the electrical components, it is necessary to develop a robotic arm that can survive these hostile settings.
7. **Mechanical instability in high-speed applications**
   A mechanically robust robotic arm is necessary for high-speed applications in order to guarantee precise and error-free operations. Conventional robotic arms are ineffective for activities demanding quick and dynamic movements because they frequently fail to maintain accuracy and stability at higher rates.

8. **Budget constraints in adopting robotic arm technology**
   Although there is no denying the advantages of robotic arm technology, financial limitations frequently prevent automation solutions from being widely adopted. Companies, particularly smaller ones, are looking for affordable solutions that offer great performance without compromising quality [37].

III. ADVANTAGES OF THE CABOT'S

1. Collaborative robots are flexible, easy to install and relocate.

Their small size makes them easy to assemble, disassemble, and relocate, moving them across the factory without changing the layout of the production. As for programming, kinesthetic guiding (hand guiding) makes robot programming accessible to everyone, not just engineers. Hand guiding allows the user to freely move the arm around in space, assigning the task himself. The demonstrated path is then recorded and can be accessed from the teaching pendant for further programming, which is usually intuitive. Such a process can take up to an hour. The quick change over time makes collaborative robots particularly interesting for SMEs (small-medium-sized enterprises) that have many different kinds of products produced at a low volume.

2. Cabot's are safer than industrial robots.

A major advantage of a Cabot over a six-axis robot is that they don't need a dedicated work cell, meaning there is no need for fences or light curtains (depending on the application, this is not always the case). That is because the robot's joints are force limited. This means that each joint is equipped with a force sensor that adds a quick reaction in case of collision, making the robot stop. Moreover, external sensors such as laser sensors can be added to slow down or stop the robot when a person approaches it.

3. Cabot's are cost-effective.

Collaborative robots may be cheaper than industrial robots (mainly because of their difference in size), although it's not only about the robots' cost but the investment as a whole. If all the side factors are taken into account, the difference in cost becomes even bigger. For example, as mentioned above, the lack of a need for a work cell and whatever that implies (hardware, human labor, and time) is cost-effective. In addition, employees do not need to undergo training, and there is no need for a robotics expert to be present to oversee or maintain the system. It is optional, as opposed to industrial robots. ROI (return on investment) takes less than a year for Cabot's, whereas for six-axis robots, it may take up to 18 months.

4. Cabot's can be two-armed and perform tasks even faster.

A feature that a few companies have added to Cabot's is a second arm, which is something not available in traditional industrial robots. The idea is that two arms can prove useful in delicate tasks like the assembly of small parts (e.g., electronics parts) or tightening screws, increasing speed and flexibility as a result. Parallel bin picking could be another application. Bin picking, the process of picking up small parts in random poses from a bin, can be executed faster with two robotic arms. A reason why two-armed Cabot's are not so popular yet is the complexity of coordinating the two arms to operate in tandem [35].

IV. DISADVANTAGES OF THE CABOT'S

1. Cabot's are not a good choice when it comes to higher loads

Flexibility comes at a price. Cabot's typically handle small payloads of 3 to 10 kg, although some models can handle up to 35 kg. On the contrary, some six-axis robots have a handling capacity of up to 2 tons, but it also depends on the application. One thing is for sure: Cabot's are not meant for heavy-duty applications.

2. Cabot speed is limited.

As safety happens to be the main focus of a Cabot, it cannot be combined with high speed, especially when extra safety measures are taken, as mentioned above. A typical Cabot's speed is 250 mm per second, four times less than a traditional industrial robot. When users interact with the Cabot, its speed is reduced to embrace safety – at the expense of cycle time. Therefore, applications that demand high speed are typically not recommended for Cabot's.

3. Cabot's might not be as efficient as six-axis robots.

Programming with hand guiding might be convenient, but it also translates to human motions (demonstrated by the employee), which might not be the optimal solution in some cases. For example, if the task requires very precise and delicate movements, human users might not be able to instruct the Cabot properly. On the other hand, industrial robots create the trajectories internally through programming, producing faster and smoother, more optimized paths as a result.

4. Cabot's are not entirely independent.

A robotic-human synergy has its drawbacks. Even though a Cabot can work 24/7 (at least in principle), its need for human assistance or supervision is still there when everyone leaves the factory at night. In contrast, industrial robots can work at full capacity without human employees.

5. Safety approval of Cabot's can be troublesome.

The safety approval of a Cabot can be troublesome, not only because there exist a great variety of safety regulations, but also, because the relocation and changes in the Cabot's tasks and/or change of tool may call for a new safety certification. This has to be done by a notified body as documentation of the CE-marking. For example, if the Cabot has a new gripper with pointy edges installed, its original function is considered changed. Therefore, one has to get a renewed safety approval, which costs time and money.

CONCLUSION

The suggested intelligent device's performance has been evaluated by having it identify arbitrary colored items from every article I have read. It is anticipated that the suggested solution will save labor expenses while boosting industry production and efficiency. In addition, I have discussed the difficulties and implications related to the Cabot's [36] as well as the difficulties it encountered.

REFERENCES

1. Rubio, F., Valero, F., & Llopis-Albert, C. (2019). A review of mobile robots: Concepts, methods, theoretical framework, and applications. International Journal of Advanced Robotic Systems, 16(2), 1729881419839596.
2. Arents, J., & Greitans, M. (2022). Smart Industrial Robot Control Trends, Challenges and Opportunities within Manufacturing. Applied Sciences, 12(2), 937.
3. Glaufe, O., Gladstone, O., Ciro, E., Carvalho, C. A. T., & José, L. (2019). Development of Robotic Arm Control System Using Computational Vision. IEEE Latin America Transactions, 17(08), 1259-1267.
4. Kelly, A., Nagy, B., Stager, D., & Unnikrishnan, R. (2007). Field and service applications-an infrastructure-free automated guided vehicle based on computer vision-an effort to make an industrial robot vehicle that can operate without supporting infrastructure. IEEE Robotics & Automation Magazine, 14(3), 24-34.
5. Tsai, C. Y., Wong, C. C., Yu, C. J., Liu, C. C., & Liu, T. Y. (2014). A hybrid switched reactive-based visual servo control of 5-DOF robot manipulators for pick-and-place tasks. IEEE Systems Journal, 9(1), 119-130.
6. Hsieh, Y. Z., & Lin, S. S. (2020). Robotic arm assistance system based on simple stereo matching and Q-learning optimization. IEEE Sensors Journal, 20(18), 10945-10954.
7. Kruse, D., Wen, J. T., & Radke, R. J. (2014). A sensor-based dual-arm tele-robotic system. IEEE Transactions on Automation Science and Engineering, 12(1), 4-18.
8. Hu, Y., Li, Z., Li, G., Yuan, P., Yang, C., & Song, R. (2016). Development of sensory-motor fusion-based manipulation and grasping control for a robotic hand-eye system. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 47(7), 1169-1180.
9. Perkasa, S. D., Megantoro, P., & Winarno, H. A. (2021). Implementation of a Camera Sensor Pixy 2 CMUcam5 to A Two Wheeled Robot to Follow Colored Object. Journal of Robotics and Control (JRC), 2(6), 469-501.
10. Gushi, S., Shimabukuro, Y., & Higa, H. (2020, November). A Self-Feeding Assistive Robotic Arm for People with Physical Disabilities of the Extremities. In 2020 5th International Conference on Intelligent Informatics and Biomedical Sciences (ICIIBMS) (pp. 61-64). IEEE.
11. Intisar, M., Khan, M. M., Islam, M. R., & Masud, M. (2021). Computer Vision Based Robotic Arm Controlled Using Interactive GUI. INTELLIGENT AUTOMATION AND SOFT COMPUTING, 27(2), 533-550.
12. Salehin, H. I., Joy, Q. R. A., Aparna, F. T. Z., Ridwan, A. T., & Khan, R. (2021, May). Development of an IoT based Smart Baby Monitoring System with Face Recognition. In 2021 IEEE World AI IoT Congress (AIIoT) (pp. 0292-0296). IEEE.
13. Rafiq, A. A., Rohman, W. N., & Riyanto, S. D. (2020). Development of a simple and low-cost smartphone gimbal with mpu-6050 sensor. Journal of Robotics and Control (JRC), 1(4), 136-140.
14. Huang, L., Wu, G., Tang, W., & Wu, Y. (2021). Obstacle Distance Measurement Under Varying Illumination Conditions Based on Monocular Vision Using a Cable Inspection Robot. IEEE Access, 9, 55955-55973.
15. Rao, N. D., & Min, J. (2018). Decent living standards: material prerequisites for human wellbeing. Social indicators research, 138(1), 225-244.
16. Kreinin, H., & Aigner, E. (2021). From "Decent work and economic growth" to "Sustainable work and economic degrowth": a new framework for SDG 8. Empirica, 1-31.
17. Gutierrez, C. A. G., Reséndiz, J. R., Santibáñez, J. D. M., & Bobadilla, G. M. (2014). A model and simulation of a five-degree-of-freedom robotic arm for mechatronic courses. IEEE Latin America Transactions, 12(2), 78-86.
18. Ahmad, M. F., Rong, H. J., Alhady, S. S. N., Rahiman, W., & Othman, W. A. F. W. (2017, November). Colour tracking technique by using pixy CMUcam5 for wheelchair luggage follower. In 2017 7th IEEE International Conference on Control System, Computing and Engineering (ICCSCE) (pp. 186-191). IEEE.
19. Marburger, J. H. (2011). Science, technology and innovation in a 21st century context. Policy Sciences, 44(3), 209-213.
20. Darmanin, R. N., & Bugeja, M. K. (2017, July). A review on multi-robot systems categorised by application domain. In 2017 25th mediterranean conference on control and automation (MED) (pp. 701-706). IEEE.
21. Voulodimos, A., Doulamis, N., Doulamis, A., & Protopapadakis, E. (2018). Deep learning for computer vision: A brief review. Computational intelligence and neuroscience, 2018.
22. Masita, K. L., Hasan, A. N., & Shongwe, T. (2020, August). Deep learning in object detection: A review. In 2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD) (pp. 1-11). IEEE.

23. Ryu, J. H., Irfan, M., & Reyaz, A. (2015). A review on sensor network issues and robotics. Journal of Sensors, 2015.
24. Sophokleous, A., Christodoulou, P., Doitsidis, L., & Chatzichristofis, S. A. (2021). Computer vision meets educational robotics. Electronics, 10(6), 730.
25. Pérez, L., Rodríguez, Í., Rodríguez, N., Usamentiaga, R., & García, D. F. (2016). Robot guidance using machine vision techniques in industrial environments: A comparative review. Sensors, 16(3), 335.
26. Jang, K. B., Baek, C. H., & Woo, T. H. (2022). Risk analysis of nuclear power plant (NPP) operations by artificial intelligence (AI) in robot. Journal of Robotics and Control (JRC), 3(2), 153-159.
27. Salim, S. A., Amin, M. R., Rahman, M. S., Arafat, M. Y., & Khan, R. (2021, September). An IoT-based Smart Agriculture System with Locust Prevention and Data Prediction. In 2021 8th International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE) (pp. 201-206). IEEE.
28. Perkasa, S. D., Megantoro, P., & Winarno, H. A. (2021). Implementation of a Camera Sensor Pixy 2 CMUcam5 to A Two Wheeled Robot to Follow Colored Object. Journal of Robotics and Control (JRC), 2(6), 469-501.
29. Jang, B., Kim, M., Harerimana, G., & Kim, J. W. (2019). Q-learning algorithms: A comprehensive classification and applications. IEEE Access, 7, 133653-133667.
30. Larsson, V., Pollefeys, M., & Oskarsson, M. (2021). Orthographic-Perspective Epipolar Geometry. In Proceedings of the IEEE/CVF International Conference on Computer Vision (pp. 5570-5578).
31. Al Tahtawi, A. R., Agni, M., & Hendrawati, T. D. (2021). Small-scale Robot Arm Design with Pick and Place Mission Based on Inverse Kinematics. Journal of Robotics and Control (JRC), 2(6), 469-475.
32. Song, K. S., Park, C. H., Kim, J., & Kang, M. G. (2016). Color interpolation algorithm for an RWB color filter array including double-exposed white channel. EURASIP Journal on Advances in Signal Processing, 2016(1), 1-12.
33. O. Gómez, J. A. Gonzalez and E. F. Morales, "Image segmentation using automatic seeded region growing and instance-based learning," Iberoamericann Congress on Pattern Recognition, pp. 192–201, 2007.
34. https://www.howtorobot.com/expert-insight/pros-and-cons-collaborative-robots-flexibility-vs-efficiency
35. Cavas, M., & Ahmad, M. B. (2019). A REVIEW ON SPIDER ROBOTIC SYSTEM. International Journal of New Computer Architectures and Their Applications, 9(1), 19-25.
36. Muhammad Ahmad Baballe, Mukhtar Ibrahim Bello, & Zainab Abdulkadir. (2022). Study on Cabot's Arms for Color, Shape, and Size Detection. Global Journal of Research in Engineering & Computer Sciences, 2(2), 48–52. https://doi.org/10.5281/zenodo.6474401.
37. https://dorna.ai/blog/robotic-arm-challenges-and-solutions/.

CITATION

Isa A.I., & Muhammad A. B. (2024). The Ups and Downs of Robotic Arms: Navigating the Challenges. In Global Journal of Research in Engineering & Computer Sciences (Vol. 4, Number 5, pp. 78–82). https://doi.org/10.5281/zenodo.13774819