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Comparison of Wrist Joint Motion Limits in Commercial Six-Axis Industrial Robots

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A B S T R A C T

Industrial robots are widely used in manufacturing applications where tool orientation and positioning are important. This study compares the wrist joint motion limits of ten commercial six-axis industrial robot configurations from ABB, KUKA, Yaskawa, and FANUC. The analysis focuses on joints 4, 5, and 6 using technical specifications published by the manufacturers. Total angular motion ranges were compared using descriptive statistics. The results showed that axis 4 had motion ranges between 370° and 460°, with a mean of 414°. Axis 5 ranged from 240° to 360°, with a mean of 281°, while axis 6 ranged from 700° to 910°, with a mean of 785°. Axis 5 showed the largest relative difference between its minimum and maximum values. The findings provide a simple comparison of wrist joint mobility and may support preliminary robot selection based on angular motion requirements.

Keywords: Industrial Robots; Six-Axis Robots; Wrist Joints; Joint Motion Limits; Angular Range; Comparative Analysis.

1. Introduction

Industrial robots have evolved from machines performing repetitive tasks into flexible systems used in modern manufacturing. Recent studies have compared commercial robot characteristics and different six-axis architectures [1,2]. Research on articulated robots has also examined trajectory geometry and methods for reducing movement length [3,4]. Other studies have focused on trajectory continuity and obstacle avoidance [5,6]. Different coordinate systems and vision-based teleoperation have provided further approaches to robotic motion and control [7,8].

The development of industrial technology has also changed how robots interact with their surroundings. Vision-based sorting and safety monitoring have become useful tools in robotic applications [9,10]. Similar progress can be observed in automated inspection and additive manufacturing [11,12]. Research on polymer materials and mechanical testing has supported the evaluation of engineering components [13,14]. Statistical comparisons and material recovery assessment have introduced additional methods for evaluating technical systems [15,16].

Technology has also evolved in human–machine interaction. Early applications included brain-to-text communication and the identification of requirements for intelligent prosthetic systems [17,18]. Later studies examined EEG-based prosthetic control and bionic leg dynamics [19,20]. Home automation and gaze-based interaction provided other examples of human-controlled systems [21,22]. Gesture recognition and personalized learning software extended digital interaction into education [23,24]. Digital therapeutic applications were also investigated [25,26]. Other studies addressed student performance and educational data governance [27,28]. Software tools were developed for assessment visualization and human resource prediction [29,30].

At the organizational level, technological development has been studied through Industry 5.0 and project management approaches [31,32]. Decision-support methods have also been applied to employee assessment and international research projects [33,34]. Network monitoring applications provide another example of digital system development [35].

Despite these advances, the mechanical characteristics of industrial robots remain important. The angular limits of the wrist joints influence the orientations that a robot can achieve. Previous studies have examined differences between robotic wrist architectures and the effects of joint motion constraints [2,36]. The present study focuses on a comparison of the angular motion limits of joints 4, 5, and 6 in selected commercial six-axis industrial robots. The analysis uses manufacturer specifications to identify differences in wrist motion capabilities.

2. Materials and Methods

This study compares the wrist joint motion limits of ten commercial six-axis industrial robot configurations from four manufacturers: ABB, KUKA, Yaskawa, and FANUC. The data were collected from publicly available manufacturer specifications and technical documentation [37–44]. Fig. 1 shows the wrist region of a six-axis industrial robot and highlights joints 4, 5, and 6 considered in this study.

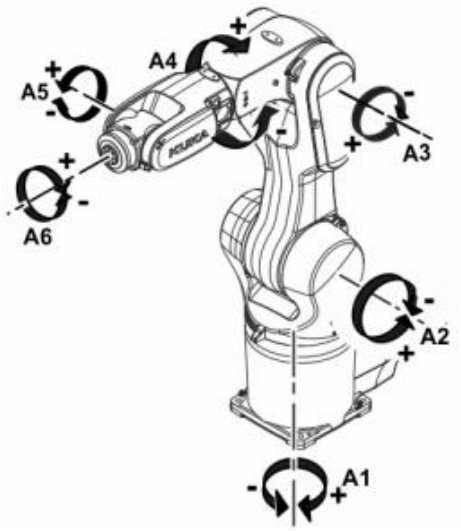


Fig. 1 - Direction of rotation of the six robot axes, including wrist axes A4, A5, and A6 (KUKA, 2019) [45].

The analysis considers the last three robot joints, identified as axes 4, 5, and 6. For Yaskawa robots, these correspond to the R, B, and T axes. The values were expressed as total angular motion ranges in degrees to allow direct comparison between manufacturers (see Table 1).

For joints with symmetric limits, the total motion range was calculated by doubling the specified positive angular limit. For example, a joint with limits of ±180° has a total range of 360°. When the manufacturer provided the total motion range directly, this value was used without modification.

Table 1 - Wrist joint motion ranges of selected industrial robots.

Manufacturer and model	Axis 4 (°)	Axis 5 (°)	Axis 6 (°)	Source
ABB IRB 1200-5/0.9 Gen2	460	260	800	[37]
ABB IRB 1200-8/0.9 Gen2	460	260	800	[37]
ABB IRB 1300-10/1.15	460	260	800	[38]
ABB IRB 1300-7/1.4	460	260	800	[38]
KUKA KR 6 R700-2	370	240	700	[39]
KUKA KR 10 R1100-2 HO	370	240	700	[40]
Yaskawa MOTOMAN GP7	380	270	720	[41]
Yaskawa MOTOMAN GP12	400	300	910	[42]
FANUC M-10iD/12	380	360	900	[43]
FANUC M-20iD/25	400	360	720	[44]

The comparison uses the motion ranges stated in the selected manufacturer documents. Optional extensions, installation restrictions, and changes in controller settings may affect the actual available motion. The data were compared using minimum, maximum, mean, and percentage differences. No physical robot tests were performed.

3. Results and Discussion

The collected data show visible differences in the wrist joint motion limits of the analyzed industrial robots. Table 1 includes ten robot configurations from ABB, KUKA, Yaskawa, and FANUC. The comparison focuses on the total angular motion ranges of axes 4, 5, and 6.

For axis 4, the recorded values ranged from 370° to 460°, with a mean value of 414°. The highest values were observed in the ABB models, which all reached 460°. The lowest values were found in the two KUKA robots, both with 370°. The difference between the minimum and maximum values was 90°, which corresponds to approximately 24.3% relative to the minimum value.

For axis 5, the motion limits ranged from 240° to 360°, with a mean value of 281°. The smallest values were again observed in the KUKA models (240°), while the largest values were found in the FANUC models (360°). The difference between the minimum and maximum values was 120°, which represents approximately 50.0% relative to the minimum value. This was the largest relative variation among the three analyzed wrist joints.

For axis 6, the values ranged from 700° to 910°, with a mean value of 785°. The highest value was identified for the Yaskawa GP12 (910°), while the lowest values were observed in the KUKA robots (700°). The difference between the minimum and maximum values was 210°, corresponding to approximately 30.0% relative to the minimum value.

A simple manufacturer-level comparison also shows some clear patterns. The ABB robots included in this study had identical wrist motion limits, with 460° for axis 4, 260° for axis 5, and 800° for axis 6. The two KUKA robots also shared the same values, namely 370°, 240°, and 700°. The Yaskawa and FANUC models showed greater internal variation, especially for axes 5 and 6.

Overall, axis 5 showed the lowest average motion range and the highest relative variation, suggesting that it is the most restrictive wrist joint among the three analyzed axes. In contrast, axis 6 had the highest motion ranges in all manufacturers, with values between 700° and 910°. This result is consistent with the functional role of the last wrist joint, which is usually designed to provide wider end-effector rotation.

These results indicate that commercial six-axis industrial robots may differ substantially in wrist mobility even when they belong to similar payload classes. The observed differences may influence robot selection in applications where orientation flexibility is important. However, a larger angular range does not automatically guarantee better practical performance, because the reachable orientations also depend on the full robot kinematic chain, tool geometry, and application constraints.

4. Conclusion

This study compared the wrist joint motion limits of ten commercial six-axis industrial robot configurations. The results showed that axis 5 had the smallest average angular range (281°) and the largest relative variation (50%). Axis 6 had the largest average range (785°), followed by axis 4 (414°). These differences show that wrist joint specifications should be considered when selecting industrial robots for tasks requiring tool orientation changes.

The analysis was limited to manufacturer specifications and did not evaluate actual robot movements. Future research will investigate how wrist joint limits, especially those of axis 5, affect tool orientation and positioning in practical robotic tasks. Additional robot models and experimental comparisons could provide a better understanding of these limitations.

References

1. Amiri, P., Müller, M., Southgate, M., Theodoridis, T., Wei, G., Richards-Brown, M., & Holderbaum, W. (2024). A statistical analysis of commercial articulated industrial robots and cobots. Journal of Manufacturing and Materials Processing, 8(5), 216. https://doi.org/10.3390/jmmp8050216
2. Boschetti, G., & Sinico, T. (2023). Performance comparison of two architectures of 6R articulated robots. Machines, 11(2), 306. https://doi.org/10.3390/machines11020306
3. Cristoiu, C. A., Drăgoi, M.-V., Ivan, A. M., Nechita, R.-M., Grecu, I., Puiu, R.-A., Petrea, G., & Popescu, E. (2025). Optimization method based on the minimum action principle for trajectory length of articulated manipulators. Technologies, 13(11), 490. https://doi.org/10.3390/technologies13110490
4. Cristoiu, C., Ivan, M., Dragoi, M. V., Popescu, E., & Nechita, R.-M. (2025). Method for qualitative evaluation of robotic trajectories based on geometric and kinematic metrics. Proceedings in Manufacturing Systems, 20(2), 69–74.
5. Cristoiu, C. A., Drăgoi, M.-V., Nechita, R.-M., Stoian, B. N., Dudici, C. L., Puiu, R.-A., & Petrea, G. (2026). The impact of geometric continuities (C1, C2, and C3) on the trajectories of industrial robots. Technologies, 14(3), 176. https://doi.org/10.3390/technologies14030176
6. Cristoiu, C. A., Drăgoi, M.-V., Nechita, R.-M., Verdete, B.-M., Dudici, C. L., & Cusma, C. N. (2026). Python software application for obstacle-avoiding path planning in RoboDK using free space graph and robot level validation. Applied Sciences, 16(10), 4786. https://doi.org/10.3390/app16104786
7. Cristoiu, C.-A., Drăgoi, M.-V., & Georgescu, V.-C. (2026). Comparative analysis of Cartesian, cylindrical and spherical grids in a graph-based obstacle-avoidance planner for industrial robots. Applied Sciences, 16(12), 6189. https://doi.org/10.3390/app16126189
8. Drăgoi, M.-V., Frimu, A.-V., Postelnicu, A., Puiu, R.-A., Petrea, G., & Hank, A. (2026). Interactive teleoperation of an articulated robotic arm using vision-based human hand tracking. Biomimetics, 11(2), 151. https://doi.org/10.3390/biomimetics11020151
9. Drăgoi, M.-V., Cristoiu, C. A., Nechita, R.-M., Navligu, B.-C., & Verdete, B.-M. (2026). A Python-based framework for learning-from-demonstration in robotic object sorting: Comparative evaluation of lightweight classifiers. Applied Sciences, 16(10), 5107. https://doi.org/10.3390/app16105107

10. Cristoiu, C. A., Drăgoi, M.-V., Cojocaru, A., & Spânu, P. (2026). A vision-based software safety monitoring tool for operators in RoboDK robotic cells: A simulation-based proof-of-concept study using workspace masks and image processing. Technologies, 14(6), 373. https://doi.org/10.3390/technologies14060373

11. Tălîngă, A.-M., Hadăr, A., Drăgoi, M.-V., Nisipeanu, I., Ali, H. A., & Suciu, C. P. (2024). YOLO-v8 in capturing imperfections generated by changing 3D printer parameters. U.P.B. Scientific Bulletin, Series C, 86(4), 253–266. https://www.scientificbulletin.upb.ro/rev_docs_arhiva/full72b_799902.pdf

12. Drăgoi, M.-V., & Cristoiu, C. A. (2026). A review of the fused deposition modeling (FDM) process: An integrated analysis of materials, manufacturing parameters, mechanical properties, defect formation, and quality assessment. International Journal of Research Publication and Reviews, 7(10), 4807–4817. https://doi.org/10.55248/gengpi.07.1026.33106

13. Tache, F.-G., Drăgoi, M.-V., Puiu, R.-A., Petrea, G., & Pascaru, R.-C. (2026). Application in research projects on the innovation found in the field of engineering of polymer and composites products. Macromolecular Symposia, 415(3), e70379. https://doi.org/10.1002/masy.70379

14. Tălîngă, A.-M., Baciu, F., Hadăr, A., Jiga, G., Drăgoi, M.-V., & Ancuța, A. (2025). Numerical and experimental study of a sandwich beam subjected to a three points bending test. U.P.B. Scientific Bulletin, Series D, 87(3), 227–240. https://www.scientificbulletin.upb.ro/static/pdfs/fulld2b_804128.pdf

15. Drăgoi, M.-V., Afram, R. M., Alzubaidi, A. A. A. M. H., Jiga, G. G., Ali, H. A., Puiu, R.-A., Petrea, G., & Hank, A. (2026). Comparative analysis of interpolation and extrapolation methods in regression models. U.P.B. Scientific Bulletin, Series C, 88(1), 145–160. https://www.scientificbulletin.upb.ro/seria/c/arhiva?year=2026

16. Nechita, R.-M., Deselnicu, D.-C., Băjenaru, V.-D., Istrițeanu, S.-E., Cristoiu, C., & Drăgoi, M.-V. (2026). Optimizing material recovery from photovoltaic waste: A performance ranking using hybrid BWM-PROMETHEE II. Sustainability, 18(8), 3750. https://doi.org/10.3390/su18083750

17. Ali, H. A., Goga, N., Vasilateanu, A., Muslim, A. M., Ali, K. A., & Drăgoi, M.-V. (2022). English and Romanian brain-to-text brain-computer interface word prediction system. International Journal of Advanced Computer Science and Applications, 13(10). https://doi.org/10.14569/IJACSA.2022.0131003

18. Drăgoi, M.-V., Hadăr, A., Goga, N., & Ali, H. A. (2022). Determining the user's requirements for an intelligent mind-controlled prosthetic lower limb system. In 2022 IEEE International Conference on Blockchain, Smart Healthcare and Emerging Technologies (SmartBlock4Health) (pp. 1–6). IEEE. https://doi.org/10.1109/SmartBlock4Health56071.2022.10034519

19. Drăgoi, M.-V., Hadăr, A., Goga, N., Grigore, L. Ș., Ștefan, A., & Ali, H. A. (2023). Design and implementation of an EEG-based BCI prosthetic lower limb using Raspberry Pi 4. U.P.B. Scientific Bulletin, Series C, 85(3), 353–366. https://www.scientificbulletin.upb.ro/static/pdfs/full704_649223.pdf

20. Drăgoi, M.-V., Hadăr, A., Goga, N., Baciu, F., Ștefan, A., Grigore, L. Ș., Gorgoteanu, D., Molder, C., & Oncioiu, I. (2023). Contributions to the dynamic regime behavior of a bionic leg prosthesis. Biomimetics, 8(5), 414. https://doi.org/10.3390/biomimetics8050414

21. Drăgoi, M.-V., Nisipeanu, I., Frimu, A., Tălîngă, A.-M., Hadăr, A., Dobrescu, T. G., Suciu, C. P., & Manea, A. R. (2024). Real-time home automation system using BCI technology. Biomimetics, 9(10), 594. https://doi.org/10.3390/biomimetics9100594

22. Drăgoi, M.-V., Nisipeanu, I., Marin, I., Cristoiu, C. A., & Alexe, C.-G. (2026). Bio-inspired gaze and neural command fusion for assistive smartphone interaction. Biomimetics, 11(7), 514. https://doi.org/10.3390/biomimetics11070514

23. Drăgoi, M.-V., Nisipeanu, I., Puiu, R.-A., Tache, F.-G., Spiridon-Mocioacă, T.-M., Hank, A., & Cristoiu, C. (2025). An inclusive offline learning platform integrating gesture recognition and local AI models. Biomimetics, 10(10), 693. https://doi.org/10.3390/biomimetics10100693

24. Drăgoi, M.-V., Puiu, R.-A., Petrea, G., Burtea, C., Spiridon-Mocioacă, T.-M., Puiu, M., & Suciu, C. P. (2025). Improving the learning process for students. Personalizing learning through software applications. U.P.B. Scientific Bulletin, Series C, 87(1), 157–166. https://www.scientificbulletin.upb.ro/rev_docs_arhiva/full465_531870.pdf

25. Goga, N., Boiangiu, C.-A., Vasilateanu, A., Popovici, A.-F., Drăgoi, M.-V., Popovici, R., Gancea, I. O., Pîrlog, M. C., Popa, R. C., & Hadăr, A. (2022). An efficient system for eye movement desensitization and reprocessing (EMDR) therapy: A pilot study. Healthcare, 10(1), 133. https://doi.org/10.3390/healthcare10010133

26. Gancea, I. O., Drăgoi, M.-V., Popovici, A.-F., Goga, N., Dragomir, R., Goga, M., & Dinu, M. C. (2020). An intelligent EMDR system for helping students with psychological problems. eLearning & Software for Education, 2, 207–214. https://doi.org/10.12753/2066-026X-20-111

27. Buzducea, C.-A., Drăgoi, M.-V., Cristoiu, C., Puiu, R.-A., Puiu, M., Petrea, G., & Navligu, B.-C. (2026). Machine learning in education: Predicting student performance and guiding institutional decisions. Education Sciences, 16(1), 76. https://doi.org/10.3390/educsci16010076

28. Drăgoi, M.-V., Puiu, R.-A., Petrea, G., Cristoiu, C. A., & Dumitrescu, C.-I. (2026). Willingness to allow educational data use for learning analytics in higher education: Trust and governance predictors: An exploratory study. Education Sciences, 16(4), 637. https://doi.org/10.3390/educsci16040637

29. Drăgoi, M., Buzducea, C., Marin, A., & Boanță, L. (2026). Assessment pressure mapper for visualizing peaks in digital evaluation load. FAIMA Business & Management Journal, 14(1), 34–42. https://faimajournal.upb.ro/archive/RevistaFAIMA_Martie2026.pdf

30. Puiu, R.-A., Drăgoi, M.-V., Tache, F.-G., Spiridon-Mocioacă, T.-M., Petrea, G., & Hank, A. (2026). Interactive attrition prediction for academic human resources management using machine learning. U.P.B. Scientific Bulletin, Series C, 88(2), 217–232. https://www.scientificbulletin.upb.ro/static/pdfs/a2026nr2c_16_16653_Roxana_Puiu_2_pag.pdf

31. Drăgoi, M.-V., Cristoiu, C. A., & Tamaș, E. A. (2026). Industry 5.0 and sustainable business models in digital transformation. FAIMA Business & Management Journal, 14(3), 57–67. https://faimajournal.upb.ro/archive/RevistaFaima_11sept2026_final.pdf

32. Drăgoi, M.-V., Șerban, D. O., Cristoiu, C. A., Boanță, L. F., & Marin, A. (2026). Hybrid project management readiness in Romanian construction companies: An exploratory survey from a small construction-company context. Buildings, 16(19), 3877. https://doi.org/10.3390/buildings16193877

33. Tache, F.-G., Drăgoi, M.-V., Puiu, R.-A., Petrea, G., & Pascaru, R.-C. (2025). A decision-support tool for evaluating employee contribution toward organizational excellence. In International Conference of Management and Industrial Engineering (Vol. 12, pp. 345–352). https://doi.org/10.56177/12icmie2025.109

34. Buzducea, C.-A., Tache, F.-G., Puiu, M., & Semenescu, A. (2026). Adaptation of innovative tools for human resource management in international research projects. Proceedings of the International Conference on Business Excellence, 20(1), 1507–1516. https://doi.org/10.2478/picbe-2026-0115

35. Drăgoi, M.-V., Maier, A. N., Alzubaidi, A. A. A. M. H., Suciu, C. P., Ali, H. A., Dobrescu, T. G., Hadăr, A., Puiu, R.-A., Petrea, G., & Avăsiloaie, A. P. (2025). Multithreading VPN application to monitor web traffic and unblock geoblocking websites. U.P.B. Scientific Bulletin, Series C, 87(4). https://www.scientificbulletin.upb.ro/static/pdfs/rez17b_486740.pdf

36. Lu, M., Wu, H., & Yuan, P. F. (2024). Optimization for industrial robot joint movement in non-horizontal 3D printing application. Architectural Intelligence, 3, 16. https://doi.org/10.1007/s44223-024-00058-z

37. ABB. (2025). Product specification: IRB 1200 Gen2. Document 3HAC074710-001, Revision A. ABB Robotics. https://new.abb.com/products/robotics/robots/articulated-robots/irb-1200-next-generation

38. ABB. (2021). IRB 1300: Class-leading performance in a compact package. Technical data sheet. ABB Robotics. https://new.abb.com/products/robotics/robots/articulated-robots/irb-1300

39. KUKA. (2024). KR 6 R700-2: Technical data. Document 0000-290-000, Version 19.1. KUKA Deutschland GmbH. https://www.kuka.com/-/media/kuka-downloads/imported/8350ff3ca11642998dbdc81dcc2ed44c/0000290000_en.pdf?hash=5EFF2125EF596829835B491468867AFF&rev=b9d6148afd9148ac9af527b90dd46fb9

40. KUKA. (n.d.). KR 10 R1100-2 HO: Technical specifications. KUKA Robotics. https://my.kuka.com/s/product/kr-10-r11002-ho/01t1i000001VMhhAAG?language=en_US

41. Yaskawa. (n.d.). GP7: High-speed handling and assembly robot—Technical specifications. Yaskawa Electric. https://www.yaskawa.co.th/products/products-robotic-motoman-robot/gp/gp7-robot

42. Yaskawa. (2020). MOTOMAN GP12: Handling and general applications with the GP Series. Technical data sheet. Yaskawa Europe GmbH. https://www.yaskawa.eu.com/Global%20Assets/Downloads/Brochures_Catalogues/Robotics/MOTOMAN_Robots/GP-Series/Flyer_Robot_GP12_E_11.2020.pdf

43. FANUC. (n.d.). M-10iD/12: Technical specifications. FANUC America. https://www.fanucamerica.com/products/robot/m-10id-12

44. FANUC. (n.d.). M-20iD/25: Technical specifications. FANUC America. https://www.fanucamerica.com/products/robot/m-20id-25

45. KUKA Deutschland GmbH. (2019). KR AGILUS-2: Specification. Version V4, Fig. 4-1, p. 18.