Journal of Mechanical Science and Technology
Volume 32, Issue 11, 1 November 2018, Pages 5411-5419

Robustness analysis of fractional order PID for an electrical aerial platform (Article)

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Abstract

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This work was performed to objectively measure and assess the robustness and tracking performance of fractional order of proportional, integral and derivative (FOPID) controller as compared to the conventional PID control. In satellite research and development, the satellite undergoes numerous tests such as thermal, acoustic and vibration tests in the cleanroom environment. However, due to space limitation in the cleanroom and the sensitive components of the satellite, it requires vibration-free, smooth and precise motion when handling the satellite. In addition, measurement interference might occur due to cable routing during procedures or tasks performed by an operator. Unlike the previous work, the robustness analysis of FOPID controller was not systematically conducted. In this paper, the analysis took into account the actuator dynamics, and various tests were considered to measure the robustness of FOPID controller. The designed FOPID controller was implemented on the scissor-type lifting mechanism of motorized adjustable vertical platform (MAVeP) model, and its performance was compared with the traditional PID controller. A comprehensive verification using MATLAB and Solidworks was carried out to generate the model and conduct the analysis . Both controllers were initially tuned using Nichol-Ziegler technique, and the additional FOPID controller parameters was tuned using the Astrom-Hagglund method. From the simulation work, it was found that the FOPID controller's tracking error was reduced between 10 % - 50 % for the disturbance rejection tests and reference to disturbance ratio (RDR) spectrum was higher as compared to PID . The analysis in this paper was predicted to be the main driver to implement FOPID controller in the complex system in the industry, especially for sensitive material handling and transportation such as satellite.

SciVal Topic Prominence

Topic: Controllers | Control | proportional integral

Prominence percentile: 97.712

Author keywords

Astrom-Hagglund and FOPID control | MAVeP | Reference to disturbance ratio | Robust control | Satellite facilities | Scissor mechanism | Ziegler-Nichols

Indexed keywords

Engineering controlled terms: Antennas | Clean rooms | Disturbance rejection | Laboratories | Materials handling | MATLAB | Proportional control systems | Robust control | Robustness (control systems) | Satellites | Three term control systems | Tools

Engineering uncontrolled terms: Cleanroom environment | Controller parameter | Fractional order pid | MAVeP | Reference to disturbance ratio | Research and development | Sensitive components | Ziegler Nichols

Engineering main heading: Controllers

Funding details

Funding sponsor	Funding number	Acronym
International Islamic University Malaysia		IIUM
International Islamic University Malaysia		IIUM
Universiti Putra Malaysia		UPM
	RIGS16-071-0235	
Kementerian Sains, Teknologi dan Inovasi	SP15-066-0188	MOSTI
Universidad Politécnica de Madrid		UPM
Council for Science, Technology and Innovation		CSTI

Funding text

This project was funded by Ministry of Science, Technology and Innovation of Malaysia (MOSTI) through ANGKASA (SP15-066-0188). This work is a collaboration of International Islamic University Malaysia (IIUM), University Putra Malaysia (UPM), SIRIM and ANGKASA to design and develop the Motorized Adjustable Vertical Platform (MAVeP) for the satellite test facilities at AITC in Malaysia. This work is also supported by the IIUM Research Initiative Grant Scheme (RIGS16-071-0235).

ISSN: 1738494X
DOI: 10.1007/s12206-018-1039-2
Source Type: Journal
Document Type: Article
Original language: English
Publisher: Korean Society of Mechanical Engineers

References (33)

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1 Leng, E.W.L., Ismail, M., Subari, M.D.

Setting-up the assembly, integration and test centre in Malaysia

(2009) *RAST 2009 - Proceedings of 4th International Conference on Recent Advances Space Technologies*, art. no. 5158244, pp. 453-458. Cited 4 times.
ISBN: 978-142443628-6
doi: 10.1109/RAST.2009.5158244

View at Publisher

2 Norsahperi, N.M.H.
(2017) *Modelling and control of base plate loading subsystem for the motorized adjustable vertical platform, Int. Conf. Mech. Automot. Aerosp. Eng. 2016, IOP Conference Series: Materials Science and Engineering*, p. 012049.

3 Leng, E.W.L., Salleh, N., Salim, H., Sabri, S.F., Ismail, M.

Design and development of Motorized Adjustable Vertical Platform (MAVeP) for satellite test facility

(2015) *International Conference on Space Science and Communication, IconSpace*, 2015-September, art. no. 7283841, pp. 424-427.
http://ieeexplore.ieee.org/xpl/conhome.jsp?punumber=1002996
ISBN: 978-147991940-6
doi: 10.1109/IconSpace.2015.7283841

View at Publisher

4 Kumar, P.
Optimal design of robust fractional order PID for the flight control system
(2015) *Int. J. Comput. Appl.*, 128 (14), pp. 31-35. Cited 4 times.

5 Zhao, J., Han, L., Wang, L., Yu, Z.

The fuzzy PID control optimized by genetic algorithm for trajectory tracking of robot arm

(2016) *Proceedings of the World Congress on Intelligent Control and Automation (WCICA)*, 2016-September, art. no. 7578443, pp. 556-559. Cited 6 times.
ISBN: 978-146738414-8
doi: 10.1109/WCICA.2016.7578443

View at Publisher

6 Song, J.-B., Byun, Y.-S., Jeong, J.-S., Kim, J., Kang, B.-S.

Experimental study on cascaded attitude angle control of a multi-rotor unmanned aerial vehicle with the simple internal model control method

(2016) *Journal of Mechanical Science and Technology*, 30 (11), pp. 5167-5182. Cited 5 times.
http://www.springerlink.com/content/1738-494X
doi: 10.1007/s12206-016-1035-3

View at Publisher

7 Al–mahturi, A., Wahid, H.
Optimal tuning of linear quadratic regulator controller using a particle swarm optimization for two–rotor aerodynamical system
(2017) *Int. J. Electr. Comput. Energ. Electron. Commun. Eng.*, 11 (2), pp. 184-190. Cited 2 times.

8 Lu, S., Lian, M., Liu, M., Cho, C., Piao, C.

Adaptive fuzzy sliding mode control for electric power steering system

(2017) *Journal of Mechanical Science and Technology*, 31 (6), pp. 2643-2650. Cited 5 times.
http://www.springerlink.com/content/1738-494X
doi: 10.1007/s12206-017-0507-4

View at Publisher

9 Jiang, X., Wang, Z., Zhang, C., Yang, L.
Fuzzy neural network control of the rehabilitation robotic arm driven by pneumatic muscles

(2015) *Industrial Robot*, 42 (1), pp. 36-43. Cited 13 times.
http://www.emeraldinsight.com/info/journals/ir/ir.jsp
doi: 10.1108/IR-07-2014-0374

View at Publisher

10 Karad, S., Chatterji, S., Suryawanshi, P.
Performance analysis of fractional order PID controller with the conventional PID controller for bioreactor control
(2012) *Int. J. Sci. Eng. Res.*, 3 (6), pp. 1-6. Cited 15 times.

11 Ahuja, A., Aggarwal, S.K.
Design of fractional order PID controller for DC motor using evolutionary optimization techniques

(2014) *WSEAS Transactions on Systems and Control*, 9 (1), pp. 171-182. Cited 9 times.
http://www.wseas.org/multimedia/journals/control/2014/a065703-184.pdf

12 Mishra, A.
Comparative study of PID and FOPID controller response for automatic voltage regulation comparative study of PID and FOPID controller response for automatic voltage regulation
(2015) *IOSR J. Eng., 4 (September)*, pp. 41-48.

13 Ramezanian, H., Balochian, S., Zare, A.
Design of optimal fractional-order PID controllers using particle swarm optimization algorithm for automatic voltage regulator (AVR) system

(2013) *Journal of Control, Automation and Electrical Systems*, 24 (5), pp. 601-611. Cited 34 times.
doi: 10.1007/s40313-013-0057-7

View at Publisher

14 Sharma, R., Gaur, P., Mittal, A.P.
Performance analysis of two-degree of freedom fractional order PID controllers for robotic manipulator with payload

(2015) *ISA Transactions*, 58, pp. 279-291. Cited 42 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/524244/description#description
doi: 10.1016/j.isatra.2015.03.013

View at Publisher

15 Çelik, V., Özdemir, M.T., Bayrak, G.
The effects on stability region of the fractional-order PI controller for one-area time-delayed load–frequency control systems

(2017) *Transactions of the Institute of Measurement and Control*, 39 (10), pp. 1509-1521. Cited 2 times.
http://www.sagepub.co.uk/journalsProdDesc.nav?prodId=Journal201831
doi: 10.1177/0142331216642839

View at Publisher

16 Çelik, V., Demir, Y.
Effects on the chaotic system of fractional order PI^{α} controller

(2010) *Nonlinear Dynamics*, 59 (1-2), pp. 143-159. Cited 10 times.
doi: 10.1007/s11071-009-9528-6

View at Publisher

17 Li, D., Ding, P., Gao, Z.
Fractional active disturbance rejection control

(2016) *ISA Transactions*, 62, pp. 109-119. Cited 20 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/524244/description#description
doi: 10.1016/j.isatra.2016.01.022

View at Publisher

18 Song, J., Wang, L., Cai, G., Qi, X.
Nonlinear fractional order proportion-integral-derivative active disturbance rejection control method design for hypersonic vehicle attitude control

(2015) *Acta Astronautica*, 111, art. no. 5364, pp. 160-169. Cited 27 times.
http://www.journals.elsevier.com/acta-astronautica
doi: 10.1016/j.actaastro.2015.02.026

View at Publisher

19 Gao, Z.
Active disturbance rejection control for nonlinear fractional-order systems

(2016) *International Journal of Robust and Nonlinear Control*, 26 (4), pp. 876-892. Cited 16 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1099-1239
doi: 10.1002/rnc.3344

View at Publisher

20 Islam, M.T., Yin, C., Jian, S., Rolland, L.
Dynamic analysis of Scissor Lift mechanism through bond graph modeling

(2014) *IEEE/ASME International Conference on Advanced Intelligent Mechatronics, AIM*, art. no. 6878277, pp. 1393-1399. Cited 4 times.
ISBN: 978-147995736-1
doi: 10.1109/AIM.2014.6878277

View at Publisher

21 Debbarma, S., Saikia, L.C., Sinha, N.
AGC of a multi-area thermal system under deregulated environment using a non-integer controller

(2013) *Electric Power Systems Research*, 95, pp. 175-183. Cited 83 times.
doi: 10.1016/j.epsr.2012.09.008

View at Publisher

22 Oldham, K., Spanier, J.
(1974) *The fractional calculus theory and applications of differentiation and integration to arbitrary order*. Cited 4326 times.

23 Podlubny, I.
(1998) *Fractional differential equations: An introduction to fractional derivatives*. Cited 12574 times.

24 Viola, J., Angel, L.
(2015) *Fractional control and robustness analysis of an inverted pendulum system*, pp. 1-6.

25 Dastranj, M.R., Rouhani, M., Hajipoor, A.
Design of optimal fractional order PID controller using PSO algorithm
(2012) *Int. J. Comput. Theory Eng.*, 4 (3), pp. 429-432. Cited 10 times.

26 Kumar, V., Patra, A.
(2016) *Application of Ziegler–Nichols method for tuning of PID controller*, pp. 138-149.

27 Dev, D.V., Usha Kumari, S.
(2014) *Modified method of tuning for fractional PID controllers*, pp. 8-10.

28 Edet, E., Katebi, R.
(2016) *Design and tuning of fractionalorder PID controllers for time–delayed processes*, pp. 1-6.

29 Padhee, S.
A novel evolutionary tuning method for fractional order PID controller
(2011) *Int. J. Soft Comput. Eng.*, 1 (3), pp. 1-9. Cited 18 times.

30 Basu, A., Mohanty, S., Sharma, R.
Designing of the PID and FOPID controllers using conventional tuning techniques

(2017) *Proceedings of the International Conference on Inventive Computation Technologies, ICICT 2016*, 2, art. no. 7824789. Cited 3 times.
ISBN: 978-150901285-5
doi: 10.1109/INVENTIVE.2016.7824789

View at Publisher

31 Alagoz, B.B., Deniz, F.N., Keles, C., Tan, N.
Disturbance rejection performance analyses of closed loop control systems by reference to disturbance ratio

(2015) *ISA Transactions*, 55, pp. 63-71. Cited 14 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/524244/description#description
doi: 10.1016/j.isatra.2014.09.013

View at Publisher

32 Ates, A., Alagoz, B.B., Yeroglu, C., Alisoy, H.
Sigmoid based PID controller implementation for rotor control

(2015) *2015 European Control Conference, ECC 2015*, art. no. 7330586, pp. 458-463. Cited 5 times.
ISBN: 978-395242693-7
doi: 10.1109/ECC.2015.7330586

View at Publisher

33 Gjone, K.
(2007) *Robustness tests and analysis of control strategies on an electro–pneumatic actuator (May)*. Cited 3 times.

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