Scopus

Documents

Adeola-Bello, Z.A.[a] , Azlan, N.Z.[a] , Hassan, S.A.A.[b]

CONTROL STRATEGY FOR POWER ASSIST UPPER LIMB REHABILITATION ROBOT WITH THE THERAPIST'S MOTION INTENTION PREDICTION

(2023) *IIUM Engineering Journal*, 24 (1), pp. 285-300.

DOI: 10.31436/iiumej.v24i1.2604

[a] Department of Mechatronics Engineering, Kulliyyah of Engineering, International Islamic University Malaysia, Jalan Gombak, Kuala Lumpur, 53100, Malaysia

[b] Department of Orthopaedics, Traumatology and Rehabilitation, Kulliyyah of Medicine, International Islamic University Malaysia Kuantan Campus, Jalan Sultan Ahmad Shah,Bandar Indera Mahkota,Pahang, Kuantan, 25200, Malaysia

Abstract

Currently, fully automated rehabilitation robots can assist therapists in providing rehabilitation therapy, hence the patients could get hurt. On the other hand, manual treatment may cause less patient injury but it is tiresome, and there are not enough therapists in most countries. Power assist rehabilitation robots can support the therapists in conducting the treatment and may help to alleviate this problem. The goal of this study is to develop a control strategy for the robot to assist the therapist's movement in a power assist upper limb rehabilitation treatment. The system combines the advantages of robotic and manual rehabilitation therapy. Torque and position sensors fitted on the power assist upper limb rehabilitation robot arm are used for motion intention estimation. The amount of angular velocity necessary to be delivered to the feedback controller will be determined by predicting the therapist's motion intention using the impedance control method. The resulting velocity from the motion intention estimator is incorporated into the Sliding Mode Control - Function Approximation Technique (SMC-FAT) based adaptive controller. The SMC-FAT based adaptive controller in the feedback loop, overcomes the uncertain parameters in the combination of the robot and the human arm. The motion intention estimator forecasts the movement of therapists. The proposed controller is used to regulate elbow flexion and extension motion on a power assist upper limb rehabilitation robot with one degree of freedom (DOF). The proposed control system has been tested using MATLAB simulation and hardware experimental tests. The outcomes demonstrate the effectiveness of the proposed controller in directing the rehabilitation robot to follow the desired trajectory based on the therapist's motion intention, with maximum errors of 0.002rad/sec, 0.005rad/sec and 0.02rad/sec for sinusoidal, constant torque values, and hardware experiment respectively.

Author Keywords

Motion intention estimator; rehabilitation robot; therapist assistance; uncertainties; Upper Limb rehabilitation

References

- Eiammanussakul, T., Sangveraphunsiri, V.
  A lower limb rehabilitation robot in sitting position with a review of training activities
  (2018) *Journal of Healthcare Engineering*, 2018, pp. 1-18.
  [1]

- Bogue, R.
  Rehabilitation robots
  (2018) *Industrial Robot*, 45 (3), pp. 301-306.
  [2]

- Alrabghi, L., Alnemari, R., Aloteebi, R., Alshammari, H., Ayyad, M., Al Ibrahim, M., Alotayfi, M., Aljuwayd, H.
  Stroke types and management
  (2018) *International Journal Of Community Medicine And Public Health*, 5 (9), p. 3715.
  [3]

- Tang, Z., Zhang, K., Sun, S., Gao, Z., Zhang, L., Yang, Z.
  An upper-limb powerassist exoskeleton using proportional myoelectric control
  (2014) *Sensors (Switzerland)*, 14 (4), p. 66776694.
  [4]

- Kadota, K., Akai, M., Kawashima, K., Kagawa, T.
Development of power-assist robot arm using pneumatic rubber muscles with a balloon sensor
(2009) *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, pp. 546-551.
[5]

- Liu, Z., Hao, J.
Intention Recognition in Physical Human-Robot Interaction Based on Radial Basis Function Neural Network
(2019) *Journal of Robotics*, 2019, pp. 1-8.
[6]

- Lee, J., Kim, M., Ko, H., Kim, K.
A control method of power-assisted robot for upper limb considering intention-based motion by using sEMG signal
(2014) *2014 11th International Conference on Ubiquitous Robots and Ambient Intelligence, URAI 2014*, pp. 385-390.
[7]

- Huang, J., Huo, W., Xu, W., Mohammed, S., Amirat, Y.
Control of Upper-Limb Power-Assist Exoskeleton Using a Human-Robot Interface Based on Motion Intention Recognition
(2015) *IEEE Transactions on Automation Science and Engineering*, 12 (4), pp. 1257-1270.
[8]

- Li, M., Deng, J., Zha, F., Qiu, S., Wang, X.
Motion Intention Estimation for Active Power-Assist Lower Limb Exoskeleton Robot (APAL)
(2018) *Preprints*, pp. 1-20.
[9]

- Chathuramali, K. G. M., Kiguchi, K.
Real-time detection of the interaction between an upper-limb power-assist robot user and another person for perception-assist
(2020) *Cognitive Systems Research*, 61, pp. 53-63.
[10]

- Struk, S., Correia, N., Guenane, Y., Revol, M., Cristofari, S.
Full-thickness skin grafts for lower leg defects coverage: Interest of postoperative immobilization
(2018) *Annales de Chirurgie Plastique Esthetique*, 63 (3), pp. 229-233.
[11]

- Wang, X., Li, X., Wang, J.
Modeling and identification of the human-exoskeleton interaction dynamics for upper limb rehabilitation
(2015) *Lecture Notes in Electrical Engineering*, 338, pp. 51-60.
[12]

- Lee, J., Kim, M., Kim, K.
A control scheme to minimize muscle energy for power assistant robotic systems under unknown external perturbation
(2017) *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 25 (12), pp. 2313-2327.
[13]

- Nomura, S., Takahashi, Y., Sahashi, K., Murai, S., Taniai, Y., Naniwa, T.
Power assist control based on human motion estimation using motion sensors for powered exoskeleton without binding legs

(2019) *Applied Sciences (Switzerland)*, 9 (1), pp. 14-16.
[14]

- Zhuang, Y., Yao, S., Ma, C., Song, R.
Admittance Control Based on EMG-Driven Musculoskeletal Model Improves the Human-Robot Synchronization
(2019) *IEEE Transactions on Industrial Informatics*, 15 (2), pp. 1211-1218.
[15]

- Wang, W., Zhang, J., Kong, D., Su, S., Yuan, X., Zhao, C.
Research on control method of upper limb exoskeleton based on mixed perception model
(2022) *Robotica*, pp. 1-17.
[16]

- Wang, W., Qin, L., Yuan, X., Ming, X., Sun, T., Liu, Y.
Bionic control of exoskeleton robot based on motion intention for rehabilitation training
(2019) *Advanced Robotics*, 33 (12), pp. 590-601.
[17]

- Yang, C., Chen, C., He, W., Cui, R., Li, Z.
Robot Learning System Based on Adaptive Neural Control and Dynamic Movement Primitives
(2019) *IEEE Transactions on Neural Networks and Learning Systems*, 30 (3), pp. 777-787.
[18]

- Shanta, M. N. T., Azlan, N. Z.
Function Approximation Technique based Sliding Mode Controller Adaptive Control of Robotic Arm with Time-Varying Uncertainties
(2015) *Procedia Computer Science*, 76, pp. 87-94.
[19]

- Osman, J.
(1990) *Modeling and control of robot manipulators*,
[20] Dissertation, City University London

- Adeola-Bello, Z., Azlan, N.
Power Assist Rehabilitation Robot and Motion Intention Estimation
(2022) *International Journal of Robotics and Control Systems*, 2 (2), pp. 297-316.
[21]

- Song, P., Yu, Y., Zhang, X.
A Tutorial Survey and Comparison of Impedance Control on Robotic Manipulation
(2019) *Robotica*, 37 (5), pp. 801-836.
[22]

- Xing, L., Wang, X., Wang, J.
A motion intention-based upper limb rehabilitation training system to stimulate motor nerve through virtual reality
(2017) *International Journal of Advanced Robotic Systems*, 14 (6), pp. 1-8.
[23]

- Topini, A., Sansom, W., Secciani, N., Bartalucci, L., Ridolfi, A., andAllotta, B.
Variable Admittance Control of a Hand Exoskeleton for Virtual Reality-Based Rehabilitation Tasks
(2022) *Frontiers in neurorobotics*, 15, p. 789743.
[24]

- Shanta, M. N. T., Azlan, N. Z.
  Adaptive sliding mode control with radial basis function neural network for time dependent disturbances and uncertainties
  (2016) *ARPN Journal of Engineering and Applied Sciences*, 11 (6), pp. 4123-4129.
  [25]

Correspondence Address
Azlan N.Z.; Department of Mechatronics Engineering, Jalan Gombak, Malaysia; email: sinnira@iium.edu.my

Publisher: International Islamic University Malaysia-IIUM

ISSN: 1511788X
Language of Original Document: English
Abbreviated Source Title: IIUM Eng. J.
2-s2.0-85149706053
Document Type: Article
Publication Stage: Final
Source: Scopus