THE ROLE OF HAPTIC FEEDBACK IN TELEOPERATION SYSTEM

Systematic Literature Review

Contents

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The role of haptic feedback in teleoperation system

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Description

Search everything published regarding the role of haptic feedback in teleoperation systems with robots.

Planning

The goal of this systematic review is to investigate the role of haptic feedback in the context of HRI in teleoperation systems. The working hypothesis consists of demonstrating whether the use of haptic feedback improves the user's interaction with the teleoperated system.

PICOC

- **Population:** Teleoperation systems composed by a haptic device and a robot.
- **Intervention:** Experimental sessions using teleoperation system with haptic device, its assessments and its feedback.
- **Comparison:**
- **Outcome:** Methodologies, methods and/or metrics to design and evaluate haptic interfaces in a teleoperation system
- **Context:** Experiments take place in research laboratory using student participants and small scale task.

Research Questions

1. Are there methodologies, methods and/or metrics to design and evaluate the usability of haptic interfaces in a teleoperation system?
2. Are there any experiments that demonstrate the effectiveness of haptic feddback in the teleoperation environment?

Keywords and Synonyms

Keyword	Synonyms
Haptic feedback	Force feedback
Haptic interface	
Haptic teleoperation	Haptic tele-operation
Methodologies	
Teleoperated robots	telerobotics
Teleoperation system	teleoperated system
Usability	accesibility, effectiveness

Search String

("haptic feedback" OR "haptic interface" OR "haptic teleoperation") AND("teleoperated robot" OR "teleoperation system")

Sources

- ACM Digital Library (http://portal.acm.org)
- IEEE Digital Library (http://ieeexplore.ieee.org)
- Scopus (http://www.scopus.com)
- Springer Link (http://link.springer.com)
- User library

Selection Criteria

Inclusion Criteria:

- Include a evaluation of haptic interface.
- Include a method or technique to design a haptic interface.
- Include one or more of the keywords, have an appropriate structure and propose some type of implementation initiative.
- Include one or more of the terms relating to the topics included in the research questions.

Exclusion Criteria:

- It is not an article
- Papers not published in a peer reviewed conference or journal.
- Papers not published in the last ten years
- Papers that covered the topic area and included the search terms, but in some other way did not match the research questions.
- Papers that included the keywords, but only to redefine general concepts.
- Papers that not included the keywords

Quality Assessment Checklist

Questions:

- Is there a clear statement of the aims of the research?
- Was the data analysis suciently rigorous?
- Is the study of value for research or practice?
- Is there a clear statement of findings?
- Was the data collected in a way that addressed the research issue?
- Was there a control group with which to compare the results?
- Was the recruitment strategy appropriate to the aims of the research?
- Was the research design appropriate to address the aims of the research?
- Is there a description of the context in which the research was carried out?
- Is the paper based on research or is it merely a report based on expert opinion)?

Answers:

- YES
- PARTLY
- NO

Data Extraction Form

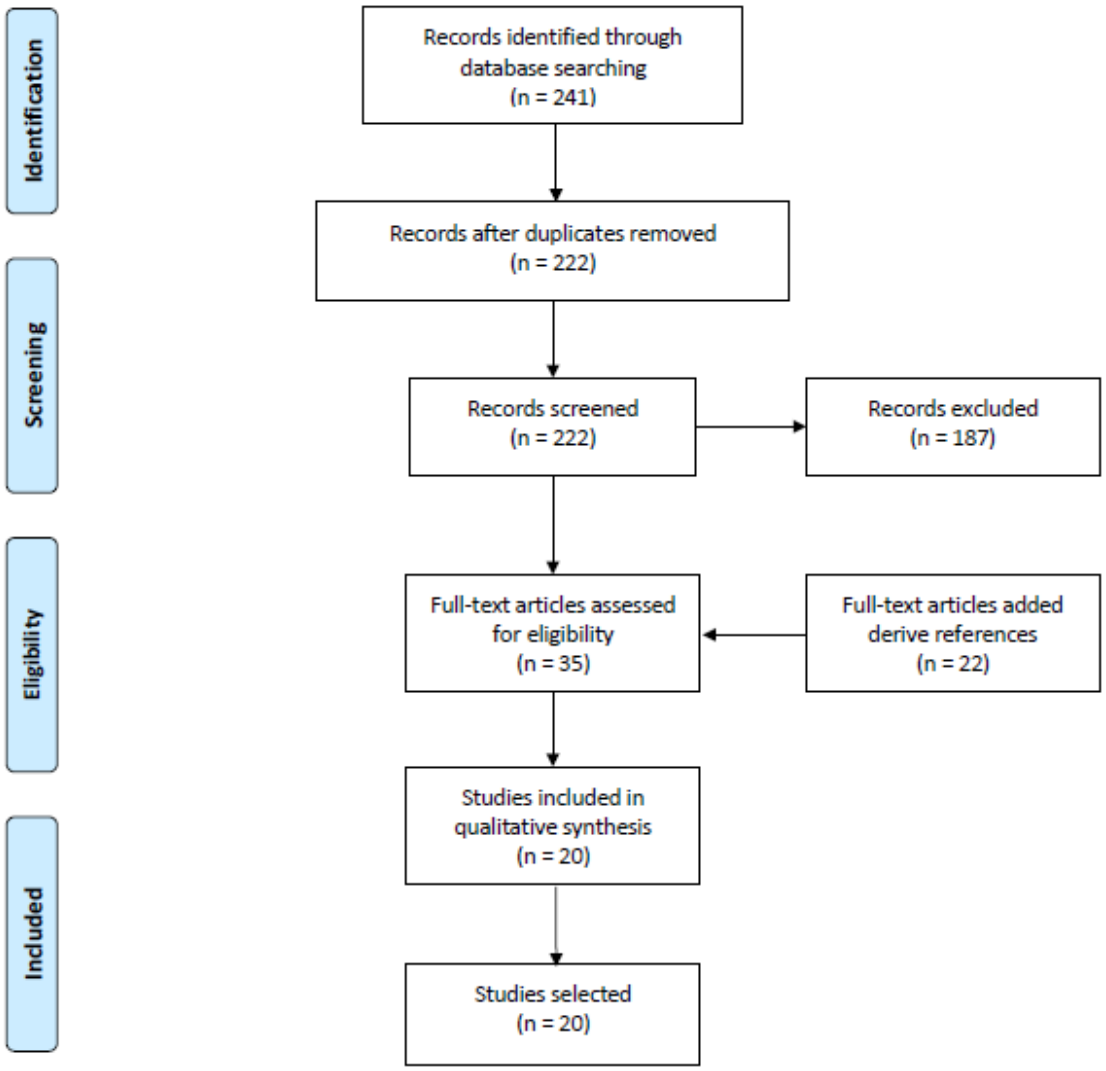
- Is there any methodology or method to design the haptic interface?
- Is there any methodology to evaluate the usability of haptic interface used?
- Is any experiment carried out?
- If the previous answer is yes, choose the evaluation method used
- Is there any experiment that demonstrate the effectiveness of haptic feddback in the teleoperation environment?
- If the previous answer is yes, How is it evaluated?

Conducting

Imported Studies

- **ACM Digital Library:** 29
- **IEEE Digital Library:** 90
- **Scopus:** 64
- **Springer Link:** 58
- **User library:** 31

PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *Preferred Reporting Items for Systematic Reviews and Meta-Analyses*: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Study Selection

Bibtex_key	Title	Author	Year
Ni_2d_2013	2D high speed force feedback teleoperation of optical tweezers	Ni, Zhenjiang and Pacoret, Cecile and Benosman, Ryad and Regnier, Stephane	2013
Guo_scaled_2019	A Scaled Bilateral Teleoperation System for Robotic-Assisted Surgery with Time Delay	Guo, Jing and Liu, Chao and Poignet, Philippe	2019
Mohand_stable_2015	A Stable and Transparent Microscale Force Feedback Teleoperation System	Mohand Ousaid, Abdenbi and Haliyo, Dogan Sinan and Regnier, Stephane and Hayward, Vincent	2015
Cheng_multilateral_2019	A multilateral impedance-controlled system for haptics-enabled surgical training and cooperation in beating-heart surgery	Cheng, Lingbo and Tavakoli, Mahdi	2019
Li20181	A novel bilateral haptic teleoperation approach for hexapod robot walking and manipulating with legs	Li, J. and You, B. and Ding, L. and Xu, J. and Li, W. and Chen, H. and Gao, H.	2018
Son20141	A psychophysical evaluation of haptic controllers: Viscosity perception of soft environments	Son, H.I. and Jung, H. and Lee, D.Y. and Cho, J.H. and Bülthoff, H.H.	2014
Rozo_robot_2013	A robot learning from demonstration framework to perform force-based manipulation tasks	Rozo, Leonel and Jiménez, Pablo and Torras, Carme	2013
Abu-dakka_adaptation_2015	Adaptation of manipulation skills in physical contact with the environment to reference force profiles	Abu-Dakka, Fares J. and Nemec, Bojan and Jørgensen, Jimmy A. and Savarimuthu, Thiusius R. and Krüger,	2015
Ebrahimi_2016	An Empirical Evaluation of Visuo-Haptic Feedback on Physical Reaching Behaviors During 3D Interaction in Real and Immersive Virtual Environments	Ebrahimi, Elham and Babu, Sabarish V. and Pagano, Christopher C. and Jörg, Sophie	2016
Liu_energy-based_2019	An energy-based approach for n-d.o.f. Passive dual-user haptic training systems	Liu, F. and Licona, A.R. and Lelevé, A. and Eberard, D. and Pham, M.T. and Redarce, T.	2019
Zhao_intuitive_2016	An intuitive human robot interface for tele-operation	Zhao, Lijun and Liu, Yihuan and Wang, Ke and Liang, Peidong and Li, Ruifeng	2016
Yamamoto_augmented_2012	Augmented reality and haptic interfaces for robot-assisted surgery	Yamamoto, T. and Abolhassani, N. and Jung, S. and Okamura, A.M. and Judkins, T.N.	2012
Lee_bayesian_2016	Bayesian framework for bilateral teleoperation systems over unreliable network	Lee, J.-Y. and Payandeh, S.	2016
Li_bilateral_2016	Bilateral teleoperation with delayed force feedback using time domain passivity controller	Li, H. and Kawashima, K.	2016
Girard_collaborative_2014	Collaborative metaphor for haptic designation in complex 3d environments	Girard, Adrien and Auvray, Malika and Ammi, Mehdi	2014
Prattichizzo_cutaneous_2012	Cutaneous force feedback as a sensory subtraction technique in haptics	Prattichizzo, D. and Pacchierotti, C. and Rosati, G.	2012
Pacchierotti_cuaneous_2015	Cutaneous haptic feedback to ensure the stability of robotic teleoperation systems	Pacchierotti, C. and Meli, L. and Chinello, F. and Malvezzi, M. and Prattichizzo, D.	2015
Zhao_design_2018	Design of a Haptic-Gripper Virtual Reality System (Hg) for Analyzing Fine Motor Behaviors in Children with Autism	Zhao, Huan and Zheng, Zhaobo and Swanson, Amy and Weitlauf, Amy and Warren, Zachary and Sarkar,	2018
Yoon_design_2015	Design of bilateral control for force feedback in surgical robot	Yoon, Sung Min and Kim, Won Jae and Lee, Min Cheol	2015
Chen_development_2017	Development of an immersive interface for robot teleoperation	Chen, Junshen and Glover, Marc and Yang, Chenguang and Li, Chunxu and Li, Zhijun and Cangelosi, Angelo	2017
Son_effect_2011	Effect of scaling on the performance and stability of teleoperation systems interacting with soft environments	Son, H.I. and Bhattacharjee, T. and Hashimoto, H.	2011
Khurshid_effects_2017	Effects of grip-force, contact, and acceleration feedback on a teleoperated pick-and-place task	Khurshid, R.P. and Fitter, N.T. and Fedalei, E.A. and Kuchenbecker, K.J.	2017
Faeth_emergent_2014	Emergent Effects in Multimodal Feedback from Virtual Buttons	Faeth, Adam and Harding, Chris	2014
Pacchierotti_engnacing_2015	Enhancing the Performance of Passive Teleoperation Systems via Cutaneous Feedback	Pacchierotti, C. and Tirmizi, A. and Bianchini, G. and Prattichizzo, D.	2015
Ju_evaluation_2019	Evaluation of Haptic Feedback in the Performance of a Teleoperated Unmanned Ground Vehicle in an Obstacle Avoidance Scenario	Ju, Chanyoung and Son, Hyoung Il	2019
Quek_evaluation_2019	Evaluation of Skin Deformation Tactile Feedback for Teleoperated Surgical Tasks	Quek, Zhan Fan and Provancher, William R. and Okamura, Allison M.	2019
Meli_experimental_2017	Experimental evaluation of magnified haptic feedback for robot-assisted needle insertion and palpation	Meli, L. and Pacchierotti, C. and Prattichizzo, D.	2017
Che_facilating_2018	Facilitating Human-Mobile Robot Communication via Haptic Feedback and Gesture Teleoperation	Che, Yuhang and Culbertson, Heather and Tang, Chih-Wei and Aich, Sudipto and Okamura, Allison M.	2018
Ni_haptic_2017	Haptic and visual augmented reality interface for programming welding robots	Ni, D. and Yew, A. W. W. and Ong, S. K. and Nee, A. Y. C.	2017
Hirche_human-oriented_2012	Human-Oriented Control for Haptic Teleoperation	Hirche, S. and Buss, M.	2012
Pacchierotti_intuitive_2015	Intuitive control of self-propelled microjets with haptic feedback	Pacchierotti, C. and Magdanz, V. and Medina-Sánchez, M. and Schmidt, O.G. and Prattichizzo, D. and Misra, S.	2015
Villaverde_passive_2012	Passive internet-based crane teleoperation with haptic aids	Villaverde, Alejandro F. and Raimúndez, Cesáreo and Barreiro, Antonio	2012
Rank_predictive_2016	Predictive Communication Quality Control in Haptic Teleoperation with Time Delay and Packet Loss	Rank, M. and Shi, Z. and Muller, H.J. and Hirche, S.	2016
Lee_preliminary_2017	Preliminary user evaluation of inaccuracy in haptic guidance for teleoperated maintenance task of nuclear power plant	Lee, Hyunjin and Ju, Chanyoung and Park, Sungjun and Park, Sangsoo and Son, Hyoung Il	2017
Neupert_pseudo-haptic_2016	Pseudo-Haptic Feedback in Teleoperation	Neupert, Carsten and Matich, Sebastian and Scherping, Nick and Kupnik, Mario and Werthschutzky, Roland and	2016
Lim_role_2015	Role of combined tactile and kinesthetic feedback in minimally invasive surgery	Lim, S.-C. and Lee, H.-K. and Park, J.	2015
Reddivari_teleoperation_2014	Teleoperation control of Baxter robot using body motion tracking	Reddivari, Hitesh and Yang, Chenguang and Ju, Z and Liang, P and Li, Z and Xu, B	2014
Li_teleoperation_2017	Teleoperation control of Baxter robot using Kalman filter-based sensor fusion	Li, Chunxu and Yang, Chenguang and Wan, Jian and Annamalai, Andy SK and Cangelosi, Angelo	2017
Ju_teleoperation_2014	Teleoperation of humanoid baxter robot using haptic feedback	Ju, Zhangfeng and Yang, Chenguang and Li, Zhijun and Cheng, Long and Ma, Hongbin	2014
Talasaz_role_2017	The Role of Direct and Visual Force Feedback in Suturing Using a 7-DOF Dual-Arm Teleoperated System	Talasaz, Ali and Trejos, Ana Luisa and Patel, Rajni V.	2017
Wildenbeest_impact_2012	The impact of haptic feedback quality on the performance of teleoperated assembly tasks	Wildenbeest, Jeroen GW and Abbink, David A and Heemskerk, Cock JM and Van Der Helm, Frans CT and	2012

Quality Assessment

Bibtex_key	Title	Quality Score
Ni_2d_2013	2D high speed force feedback teleoperation of optical tweezers	6.0
Guo_scaled_2019	A Scaled Bilateral Teleoperation System for Robotic-Assisted Surgery with Time Delay	7.5
Mohand_stable_2015	A Stable and Transparent Microscale Force Feedback Teleoperation System	7.0
Cheng_multilateral_2019	A multilateral impedance-controlled system for haptics-enabled surgical training and cooperation in beating-heart surgery	7.5
Li20181	A novel bilateral haptic teleoperation approach for hexapod robot walking and manipulating with legs	7.0
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Rozo_robot_2013	A robot learning from demonstration framework to perform force-based manipulation tasks	8.0
Abu-dakka_adaptation_2015	Adaptation of manipulation skills in physical contact with the environment to reference force profiles	9.0
Ebrahimi_2016	An Empirical Evaluation of Visuo-Haptic Feedback on Physical Reaching Behaviors During 3D Interaction in Real and Immersive Virtual Environments	9.0
Liu_energy-based_2019	An energy-based approach for n-d.o.f. Passive dual-user haptic training systems	8.0
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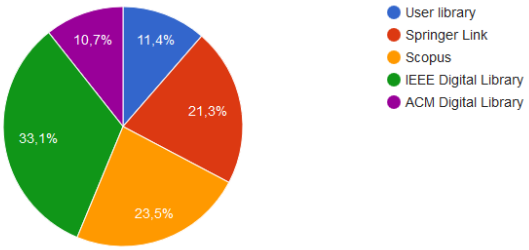
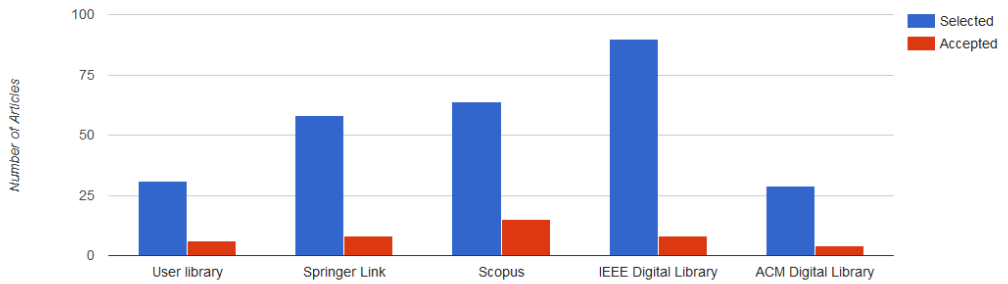
Data analysis

Articles Per Source



Accepted Articles Per Source



Final Articles Per Year (After study selection and quality assessment)