TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR. GORDON CHENG

October 17, 2022

P R A C T I C A L   C O U R S E
for
student name, Mat.-Nr. maticulation number

Detecting object relationship from vision for cooking robot scene understanding

Problem description:

Cooking robot arm have to perform tasks such as grabbing, pouring, cutting ingredients. They navigate in unconstrained environment, thus a good understanding of their surroundings is needed to complete their tasks. The scene is analysed through vision via depth cameras, fixed to the robot gripper and external to the robot. The aim of this project is to detect the objects and their relationship (in contact, inside, above,...etc) in order to describe the environment in a comprehensive graph.

Tasks:

- Do a literature review on the existing methods [1] [2] [3] [4] [5] for describing the environment and obtaining this description using vision
- Identify what will be specific needs and advantages of the cooking robot scenario
- Select an environment description and object relationship detection method that fits the cooking robot needs
- Apply this method for the Franka Emika Panda robot arm cooking with fruit toys

Bibliography:

[1] Stephan Baier, Yunpu Ma, and Volker Tresp. Improving Visual Relationship Detection using Semantic Modeling of Scene Descriptions, September 2018. arXiv:1809.00204 [cs].

[2] Yu-Wei Chao, Yunfan Liu, Xieyang Liu, Huayi Zeng, and Jia Deng. Learning to Detect Human-Object Interactions. In *2018 IEEE Winter Conference on Applications of Computer Vision (WACV)*, pages 381–389, Lake Tahoe, NV, March 2018. IEEE.

[3] Bo Dai, Yuqi Zhang, and Dahua Lin. Detecting Visual Relationships with Deep Relational Networks. In *2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 3298–3308, Honolulu, HI, July 2017. IEEE.

[4] Cewu Lu, Ranjay Krishna, Michael Bernstein, and Li Fei-Fei. Visual Relationship Detection with Language Priors, July 2016. arXiv:1608.00187 [cs].

[5] Guoyu Zuo, Jiayuan Tong, Hongxing Liu, Wenbai Chen, and Jianfeng Li. Graph-Based Visual Manipulation Relationship Reasoning Network for Robotic Grasping. *Frontiers in Neurorobotics*, 15, 2021.

Supervisor: M.Sc. Camille Vindolet

(G. Cheng)
Univ.-Professor

TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR. GORDON CHENG

October 24, 2022

P R A C T I C A L   C O U R S E
for
Student Name, Mat.-Nr. XXXXXXX

Experimental Evaluation of several Shared Control Architectures for bilteral teleoperation of contact Tasks

Problem description:

Shared Control provides means to combine human problem solving and cognitive abilities, with the precision and reliability of robotic execution. The idea in shared control is that an Autonomous agent encodes some form of task knowledge, which is then exploited to deliver a degree of assistance to perform the task. For instance, the control space can be partitioned such that the autonomy controls a subset of the degrees of freedom, while the human is in charge of the rest [4, 3]. Another possibility is to fuse human inputs with the outputs of the autonomous agent depending on some authority allocation metric [1]. Alternatively, virtual fixtures can be devised to provide haptic guidance rendered on the master interface, which can guide the operator along a desired path [2]. In this work, we aim to validate several shared control architectures for the teleoperated execution of a drawing task. Your task will be to extend an existing hardware setup and a developed learning based shared control algorithm with several shared control architectures, as well as the validation of these approach in a user study.

Tasks:

- Understand the fundamental concepts of shared control and haptic guidance
- Propose and implement potential shared control architectures that can be suited for the task
- Conduct a user study based on the proposed schemes
- Quantitative and qualitative analysis of the obtained results.

Bibliography:

[1] Anca D Dragan and Siddhartha S Srinivasa. A policy-blending formalism for shared control. *The International Journal of Robotics Research*, 32(7):790–805, 2013.

[2] Carolina Passenberg, Raphaela Groten, Angelika Peer, and Martin Buss. Towards real-time haptic assistance adaptation optimizing task performance and human effort. In *IEEE World Haptics Conference*, pages 155–160, 2011.

[3] Affan Pervez, Hiba Latifee, Jee-Hwan Ryu, and Dongheui Lee. Motion encoding with asynchronous trajectories of repetitive teleoperation tasks and its extension to human-agent shared teleoperation. *Autonomous Robots*, 43(8):2055–2069, 2019.

[4] Michael Young, Christopher Miller, Youyi Bi, Wei Chen, and Brenna D. Argall. Formalized task characterization for human-robot autonomy allocation. In *International Conference on Robotics and Automation (ICRA)*, pages 6044–6050, 2019.

Supervisor: M. Sc. Youssef Michel Abdelwadoud

(G. Cheng)
Univ.-Professor

TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR.-ING. GORDON CHENG

October 26, 2022

P R A C T I C A L   C O U R S E
for
Student name, Mat.-Nr. matriculation number

The role of dynamic similarity for entrainment with a haptic stimulus

Problem description:

Dynamic similarity has shown to facilitate interpersonal synchronization in a joint action with visual feedback [5]. Synchronization (entrainment) of a human's movements with an external stimulus, can be also observed e.g. during haptic interaction with another person [2, 3] or a moving reference [1, 4, 6]. Moreover, it has been shown that entrainment is greater in individuals with a closer social relationship [2]. Thus, the question arises, to what extent does the level of entrainment relate to the amount of dynamic similarity? To answer this question, your task will be:

Tasks:

- Literature research
- Data post-processing and analysis
- Statistical analysis
- Answer the research question and discuss with respect to literature

Bibliography:

[1] Lorenz Assländer, Craig P. Smith, and Raymond F. Reynolds. Sensory integration of a light touch reference in human standing balance. *PLOS ONE*, 13(6):e0197316, June 2018.

[2] Tomoya Ishigaki, Ryota Imai, and Shu Morioka. Association between Unintentional Interpersonal Postural Coordination Produced by Interpersonal Light Touch and the Intensity of Social Relationship. *Frontiers in Psychology*, 8:1993, November 2017.

[3] Leif Johannsen, Alan M. Wing, and Vassilia Hatzitaki. Contrasting effects of finger and shoulder interpersonal light touch on standing balance. *Journal of Neurophysiology*, 107(1):216–225, January 2012.

[4] G. Schoner, T.M.H. Dijkstra, and J.J. Jeka. Action-Perception Patterns Emerge From Coupling and Adaptation. *Ecological Psychology*, 10(3-4):323–346, September 1998. Publisher: Routledge _eprint: https://doi.org/10.1080/10407413.1998.9652688.

[5] Piotr Słowiński, Chao Zhai, Francesco Alderisio, Robin Salesse, Mathieu Gueugnon, Ludovic Marin, Benoit G. Bardy, Mario di Bernardo, and Krasimira Tsaneva-Atanasova. Dynamic similarity promotes interpersonal coordination in joint action. 13(116):20151093.

[6] Alan M. Wing, Leif Johannsen, and Satoshi Endo. Light touch for balance: influence of a time-varying external driving signal. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1581):3133–3141, November 2011.

Supervisor: M. Sc. Katrin Schulleri

(G. Cheng)
Univ.-Professor

TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR. GORDON CHENG

October 26, 2022

P R A C T I C A L   C O U R S E
for
Student's name, Mat.-Nr. XXX

Integration of pressure insoles, IMU sensors and haptic belt for real-time biofeedback

Problem description:

Wearable devices have been developed and investigated [8] for improving postural control. They provide a good opportunity for the application in everyday life [7]. Especially vibrotactile feedback is feasible for applications in everyday life, since it is unobstrusive [9] and not restricting other sensory functions, such as seeing, hearing, tasting [1]. Previous studies have used vibrotactile feedback at different locations [2], most commonly around the waist [4, 5, 10, 12]. However, reaction times to vibrotactile feedback are faster at locations closer to the head, except for the fingertips due their higher tactile sensitivity [2]. Thus, recently a vibrotactile vest was investigated [11]. However, only a local reduction of tilt angle deviation at the lower back could be observed, while center of pressure (CoP) displacement did increase [11]. Though, previous studies with a vibrotactile belt showed a reduction of body sway at both low back and CoP [3, 6]. It remains unknown, if these different observations are due to the location of the feedback or to what extent also the location of the reference system plays a role.

Tasks:

- either build vibrotactile belt (e.g. 1-2 students)
- or integrate Moticon pressure insoles in C++ code for real-time streaming (e.g. 1-2 students)
- or integrate Xsens dot sensors in C++ code for real-time streaming (e.g. 1-2 students)
- compute body sway threshold based on different reference locations and systems: upper back (IMU), lower back (IMU), feet (pressure insoles)
- combine different systems and codes for application of real-time biofeedback
- conduct pilot study with application of real-time biofeedback by haptic belt and evtl. haptic vest using pressure insoles and IMUs as reference sensors
- data collection and analysis
- compare the effect of repulsive biofeedback on body sway 1) resulted from different reference sensor locations (upper back, lower back, feet), 2) and evtl. resulted from a vibrotactile vest vs. a vibrotactile belt compared to no feedback condition to answer the research question.

Bibliography:

[1] Giulia Ballardini, Valeria Florio, Andrea Canessa, Giorgio Carlini, Pietro Morasso, and Maura Casadio. Vibrotactile Feedback for Improving Standing Balance. *Frontiers in bioengineering and biotechnology*, 8, 2020.

[2] Tian Bao, Lydia Su, Catherine Kinnaird, Mohammed Kabeto, Peter B. Shull, and Kathleen H. Sienko. Vibrotactile display design: Quantifying the importance of age and various factors on reaction times. *PLOS ONE*, 14(8):1–20, 08 2019.

[3] Zuzana Hirjaková, Jana Lobotková, Kristina Buckova, Diana Bzdúšková, and Frantisek Hlavacka. Age-Related Differences in Efficiency of Visual and Vibrotactile Biofeedback for Balance Improvement. *Activitas Nervosa Superior Rediviva*, 57(3):63–71, 2015.

[4] Catherine Kinnaird, Jaehong Lee, Wendy Carender, Mohammed Kabeto, Bernard Martin, and Kathleen Sienko. The effects of attractive vs. repulsive instructional cuing on balance performance. *Journal of neuroengineering and rehabilitation*, 13, 2016.

[5] B.-C. Lee, B. J. Martin, and K. H. Sienko. Directional Postural Responses Induced by Vibrotactile Stimulations Applied to the Torso. *Experimental brain research*, 222(4):471–482, 2012.

[6] Chia-Cheng Lin, Susan L. Whitney, Patrick J. Loughlin, Joseph M. Furman, Mark S. Redfern, Kathleen H. Sienko, and Patrick J. Sparto. The effect of age on postural and cognitive task performance while using vibrotactile feedback. *Journal of neurophysiology*, 113 7:2127–36, 2015.

[7] C. Z. Ma, A. H. Wan, D. W. Wong, Y. P. Zheng, and W. C. Lee. A vibrotactile and plantar force measurement-based biofeedback system: Paving the way towards wearable balance-improving devices. *Sensors (Basel)*, 15:31709–22, 2015.

[8] D. W. Ma, C. Z.and Wong, W. K. Lam, A. H. Wan, and W. C. Lee. Balance improvement effects of biofeedback systems with state-of-the-art wearable sensors: A systematic review. *Sensors (Basel)*, 16:434, 2016.

[9] Jussi Rantala, Päivi Majaranta, Jari Kangas, Poika Isokoski, Deepak Akkil, Oleg Špakov, and Roope Raisamo. Gaze Interaction With Vibrotactile Feedback: Review and Design Guidelines. *Human–Computer Interaction*, 35(1):1–39, 2017.

[10] Kathleen H. Sienko, Rachael D. Seidler, Wendy J. Carender, Adam D. Goodworth, Susan L. Whitney, and Robert J. Peterka. Potential mechanisms of sensory augmentation systems on human balance control. *Frontiers in Neurology*, 9:944, 2018.

[11] Isabel Tannert, Katrin H Schulleri, Youssef Michel, Steeven Villa, Leif Johannsen, Joachim Hermsdorfer, and Dongheui Lee. Immediate effects of vibrotactile biofeedback instructions on human postural control. *Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual International Conference*, 2021:7426—7432, November 2021.

[12] Conrad Wall. Application of Vibrotactile Feedback of Body Motion to Improve Rehabilitation in Individuals with Imbalance. *Journal of Neurologic Physical Therapy*, 34(2):98–104, 2010.

Supervisor: M. Sc. Katrin Schulleri

(G. Cheng)
Univ.-Professor