Research Statement

Research areas: Software engineering, human-computer interaction, robotics, augmented and virtual reality.

Overview

Software development is difficult, especially for novices. When working with new technology, even experienced programmers face challenges. As a researcher in Software Engineering, my work is focused on the support of inexperienced developers and, similarly, experienced developers working with new technology. My most recent studies are based on human-robot collaboration, where I investigate techniques to support end-users without programming experience in software development tasks. These studies are part of a growing topic, end-user robot programming, which is of massive practical interest to robot manufacturers. As a result of my work, tools such as Duplo and Mista have been implemented, attracting the attention of conferences (see https://bit.ly/icse-paper) and public media (see https://bit.ly/governor-visit). I also have been exploring developer support in open-source software communities. With more than ten papers published on the topic, my studies merge the knowledge of areas such as machine learning and statistics with the challenges developers face while collaborating on open-source projects.

End-User Programming in Robotics

Robot sales are increasing year after year [1]. As I recently was served coffee by a robot, I realized that what our parents considered science-fiction is now reality. Economics experts explain the dramatic and continued uptick in robotics by a change in the mindset of manufacturers, who are now automating a broader set of tasks than ever before [2]. To work in these varied contexts, robot manufacturers have invested resources in a new type of robot: the collaborative robot. Different from traditional industrial robots surrounded by cages on the factory floor, collaborative robots are made to work safely around humans in any workspace. Many hardware advancements in robot technology allowed such robots to become reliable, but the corresponding software support has lagged behind, and the problems this created soon became obvious. How do robot manufacturers sell high-tech robots to a broader audience if they don't know how to program them? [3]. This question, and similar research challenges, became so pressing that in 2011 NSF created a major program, the Robotics Research Initiative (NRI), trying to attract researchers to the field (see https://bit.ly/nsf-nri).

My work has focused on making robot programming more accessible by combining knowledge from software engineering with robotics. One of my latest tools, Duplo, explores the use of the block-based programming paradigm to assist end-users with two-armed robot programming [4]. With 52 participants trying the tool in a task-based experiment, we found that Duplo allows users to implement parallel programs faster and with more success than with solutions provided by the manufacturers. During this work we discovered additional challenges, such as how to accurately visualize robot arm positions in a program, which is necessary to understand the program. Since then, we have implemented support in augmented reality and are currently testing this approach with users. Each step of this work—enabling easy programming with blocks or visualizing robot paths with augmented reality—brings us one step closer to the ultimate goal of empowering end-users to teach robots to do their work tasks without extensive training.

Selected publications: ICSE 2024 [4], ICSE 2023 [5], OOPSLA 2022 [6].
Latest video: https://bit.ly/duplo-video

Newcomers in Open Source Communities

Open-source communities are known for supporting and implementing many applications [7]. From system-related programs such as the Linux Kernel to programming languages like Python, open-source development plays an essential role in the software industry. While propriety software depends on the hiring of employees in a company-based model, open-source communities benefit from collaborations from both employees and volunteers. The critical challenge to keep such communities alive is to gather sufficient volunteers. As most open-source projects are primarily available online, the gateway to these projects tends to be their websites and coding repositories, where limited support is available [8]. As an experienced researcher on the topic, my goal is to keep investigating ways to support new contributors in open-source communities. So far, I have explored potential barriers newcomers face in those projects and implemented solutions to help them join communities. Two of my latest studies benefit from supervised learning models to explore the support of newcomers. The first one uses a set of variables (e.g., commits, forks) extracted from

popular open-source projects, and clustering algorithms, to identify what factors influence newcomers to onboard new projects [9]. The second uses manually classified documentation files to recommend to newcomers what paragraphs are relevant in a documentation file during their onboarding process [4]. From the outcomes, tools such as CONTRIBUTING.info (see https://bit.ly/ml-tool), a natural language classifier, emerged to support new contributors.

Selected publications: TSE 2020 [10], EMSE 2018 [11], ICSME 2016 [12].
Latest video: https://bit.ly/newcomers-video

Breaking Barriers in Other Domains

Inexperienced developers are everywhere. While some may have programming education but are struggling to advance in more complex topics (e.g., newcomers in open-source projects), others are still facing the challenges of basic tasks (e.g., end-users in robotics). No matter their level of knowledge, my goal as a researcher is to keep contributing to their success. As a last overview, I highlight two other papers I have worked on. The first paper focused on Ladder Logic, one of the only programming languages available for programmable logic controllers [13]. This paper brought emphasis to the impact of programming languages on industrial settings, discussed the importance of supporting new developers in the context, and was a runner-up for the best paper of the year in the Journal of Computer Languages. The second is a paper started during the COVID-19 pandemic, where we investigated how virtual reality devices could mitigate the challenges of working from home [14]. This paper brought light to the life of developers working remotely, a growing work style in the last few years.

Latest video: https://bit.ly/vr-remote

References

[1] K. De Backer, T. DeStefano, C. Menon, and J. R. Suh, "Industrial robotics and the global organisation of production," 2018.

[2] M. Knudsen and J. Kaivo-Oja, "Collaborative robots: Frontiers of current literature," *Journal of Intelligent Systems: Theory and Applications*, vol. 3, no. 2, pp. 13–20.

[3] I. Aaltonen and T. Salmi, "Experiences and expectations of collaborative robots in industry and academia: Barriers and development needs," *Procedia Manufacturing*, vol. 38, pp. 1151–1158, 2019.

[4] F. Fronchetti, N. Ritschel, L. Schorr, C. Barfield, G. Chang, R. Spinola, R. Holmes, and D. C. Shepherd, "Block-based programming for two-armed robots: A comparative study," 2024.

[5] N. Ritschel, F. Fronchetti, R. Holmes, R. Garcia, and D. C. Shepherd, "Enabling end-users to implement larger block-based programs," in *Proceedings of the ACM/IEEE 44th International Conference on Software Engineering: Companion Proceedings*, pp. 347–349, 2022.

[6] N. Ritschel, F. Fronchetti, R. Holmes, R. Garcia, and D. C. Shepherd, "Can guided decomposition help end-users write larger block-based programs? a mobile robot experiment," *Proceedings of the ACM on Programming Languages*, vol. 6, no. OOPSLA2, pp. 233–258, 2022.

[7] K. Blind, M. Böhm, P. Grzegorzewska, A. Katz, S. Muto, S. Pätsch, and T. Schubert, "The impact of open source software and hardware on technological independence, competitiveness and innovation in the eu economy," *Final Study Report. European Commission, Brussels, doi*, vol. 10, p. 430161, 2021.

[8] I. Steinmacher, M. A. G. Silva, M. A. Gerosa, and D. F. Redmiles, "A systematic literature review on the barriers faced by newcomers to open source software projects," *Information and Software Technology*, vol. 59, pp. 67–85, 2015.

[9] F. Fronchetti, I. Wiese, G. Pinto, and I. Steinmacher, "What attracts newcomers to onboard on oss projects? tl; dr: Popularity," in *Open Source Systems: 15th IFIP WG 2.13 International Conference, OSS 2019, Montreal, QC, Canada, May 26–27, 2019, Proceedings 15*, pp. 91–103, Springer, 2019.

[10] H. S. Padala, C. Mendez, F. Fronchetti, I. Steinmacher, Z. Steine-Hanson, C. Hilderbrand, A. Horvath, C. Hill, L. Simpson, M. Burnett, *et al.*, "How gender-biased tools shape newcomer experiences in oss projects," *IEEE Transactions on Software Engineering*, vol. 48, no. 1, pp. 241–259, 2020.

[11] G. Pinto, I. Steinmacher, L. F. Dias, and M. Gerosa, "On the challenges of open-sourcing proprietary software projects," *Empirical Software Engineering*, vol. 23, pp. 3221–3247, 2018.

[12] L. F. Dias, I. Steinmacher, G. Pinto, D. A. Da Costa, and M. Gerosa, "How does the shift to github impact project collaboration?," in *2016 IEEE international conference on software maintenance and evolution (ICSME)*, pp. 473–477, IEEE, 2016.

[13] F. Fronchetti, N. Ritschel, R. Holmes, L. Li, M. Soto, R. Jetley, I. Wiese, and D. Shepherd, "Language impact on productivity for industrial end users: A case study from programmable logic controllers," *Journal of Computer Languages*, vol. 69, p. 101087, 2022.

[14] A. Ruvimova, F. Fronchetti, B. A. Kahn, L. H. Susin, Z. Hurley, T. Fritz, M. Hancock, and D. Shepherd, "Ready worker one? high-res vr for the home office," in *Proceedings of the 29th ACM Symposium on Virtual Reality Software and Technology*, pp. 1–12, 2023.