Underrepresentation of Women in Robotics Research

By Elizabeth Fields, Chloe Ho, Min Jie Kim, Zixuan Wu, and Brian Plancher

Computer science (CS) and engineering research both have large and well-documented gender diversity gaps [1], [2], [3]. In fact, previous studies have reported that the overall CS female author ratio (FAR) is only in the range of 16%–26% [1], [3], [4]. As shown in Table 1, recent evidence shows that this number varies significantly among CS subfields, ranging from as high as 42% in CS education to as low as 8% in theory and algorithms [1], [4]. Furthermore, while recent work has shown that the diversity in conference leadership has increased substantially over recent years [5] and that the state of gender diversity in marine robotics ranges from 7% to 44% across various countries in Europe [6], there has not been a comprehensive study analyzing the current state of gender diversity across the broader overall field of robotics.

To begin to address this gap, we recently collected and analyzed the gender of paper authors from all IEEE Robotics and Automation Society (RAS) fully sponsored conferences (ARSO, CASE, HAPTICS, Humanoids, ICRA, ISAM, MEMS, RoboSoft, SIMPAR, and SSRR) as well as IROS from 2019 to 2021. As many ICRA and IROS papers were dual-submitted to *IEEE Robotics and Automation Letters* (*RA-L*) during this timeframe, we also added all articles published in *RA-L* over that same timeframe to our analysis. Overall, we find that robotics has a long way to go to reach gender parity, with an overall FAR of only 11%–12%. We hope this analysis helps the robotics community continue to emphasize the importance of working to improve our diversity.

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METHODOLOGY

We used the Python Selenium and BeautifulSoup libraries to scrape the first and last authors of the following IEEE RAS fully sponsored conferences plus IROS and *RA-L* held or published in 2019, 2020, and 2021 from IEEE *Xplore*:

- *ARSO*: IEEE Workshop on Advanced Robotics and Its Social Impacts
- *CAS*: IEEE International Conference on Automation Science and Engineering
- *HAPTICS*: IEEE Haptics Symposium
- *Humanoids*: IEEE RAS International Conference on Humanoid Robots
- *ICRA*: IEEE International Conference on Robotics and Automation
- *ISAM*: IEEE International Symposium on Assembly and Manufacturing
- *MEMS*: IEEE International Conference on Micro Electro Mechanical Systems
- *RoboSoft*: IEEE International Conference on Soft Robotics
- *SIMPAR*: IEEE International Conference on Simulation, Modeling, and Programming for Autonomous Robots
- *SSRR*: IEEE International Symposium on Safety, Security, and Rescue Robotics
- *IROS*: IEEE/Robotics Society of Japan International Conference on Intelligent Robots and Systems
- *RA-L*: *IEEE Robotics and Automation Letters*

We note that not all conferences occurred all three years, and ISAM and SIMPAR were not held at all during this timeframe.

As shown in Figure 1, for many authors, we were able to derive their gender marker from their official IEEE *Xplore* author biography (43%). For all other authors,

TABLE 1. FAR for CS and engineering subfields based on prior work and including our result for robotics [1], [3], [4] (data from 2017 to 2023).

FIELD	FAR (%)
CS education	42
Human–computer interaction	26
CS overall average	**16–26**
Knowledge systems	19
Software engineering and languages	14
Artificial intelligence	12
Robotics	**11–12 (our analysis)**
Computer systems	10
Theory and algorithms	8

we followed the methodology used by Frachtenberg and Kaner [1] and manually labeled them by looking through alternative author profiles using search engines, such as LinkedIn (15%), Google Scholar (9%), or ResearchGate (4%), as well as by locating the author's affiliated university or company profile page (13%) or personal webpage (5%). Where the author was not searchable, we leveraged the Genderize.io service (10%). Following Frachtenberg and Kaner [1], we only used the gender reported from Genderize.io if the confidence was ≥70% and otherwise labeled the author as "unknown." [Where possible, country codes for the authors' affiliations were used to maximize accuracy. Out of 12,878 total authors, only 340 (2.6%) were labeled as "unknown."] As has been noted in related works, this kind of methodology has many flaws and does not take into account much of the nuance in gender, including issues of bias, misperception, and nonbinary identities [7], [8]. However, we hope that this initial study will help add to the robotics community's understanding of the current state of gender diversity and, at a minimum, provide directionally correct data to help with future diversity, equity, and inclusion efforts.

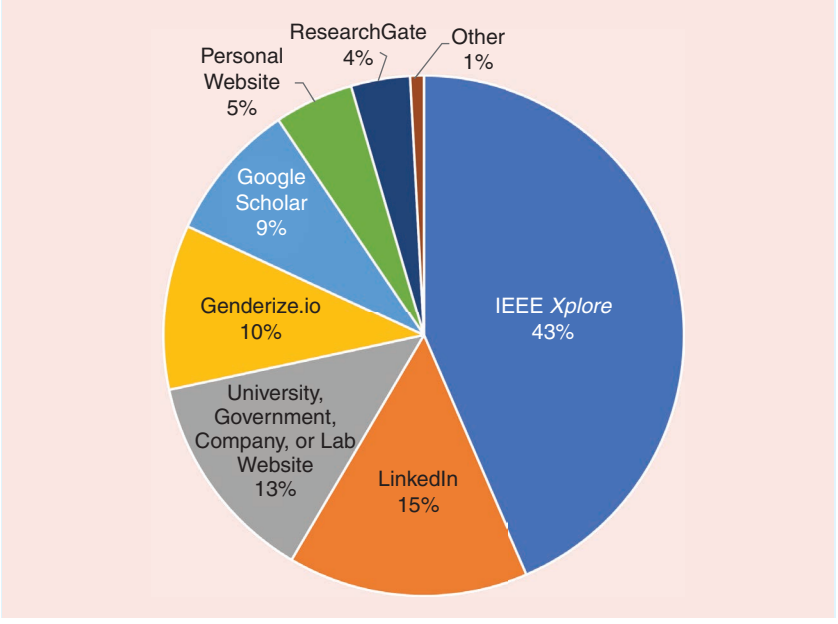

FIGURE 1. The data sources used to determine author gender.

RESULTS

These conferences and journal totaled 11,629 papers and articles with 12,878 unique first and last authors. Overall, as shown in Figure 2, we find that the FAR is as low as 6% and as high as 24%, with an overall average of 11%–12%. Although 2019–2021 represented a shift from in-person to online conferences during the COVID-19 pandemic and an increased focus on diversity, equity, and inclusion by RAS and the larger IEEE and robotics communities, we did not find any significant trends in FAR over this time. Similarly, even though the faculty pipeline is known to be leaky, and, as such, we hypothesized that there would be more female graduate students than professors and, thus, more female first authors, we did not find a

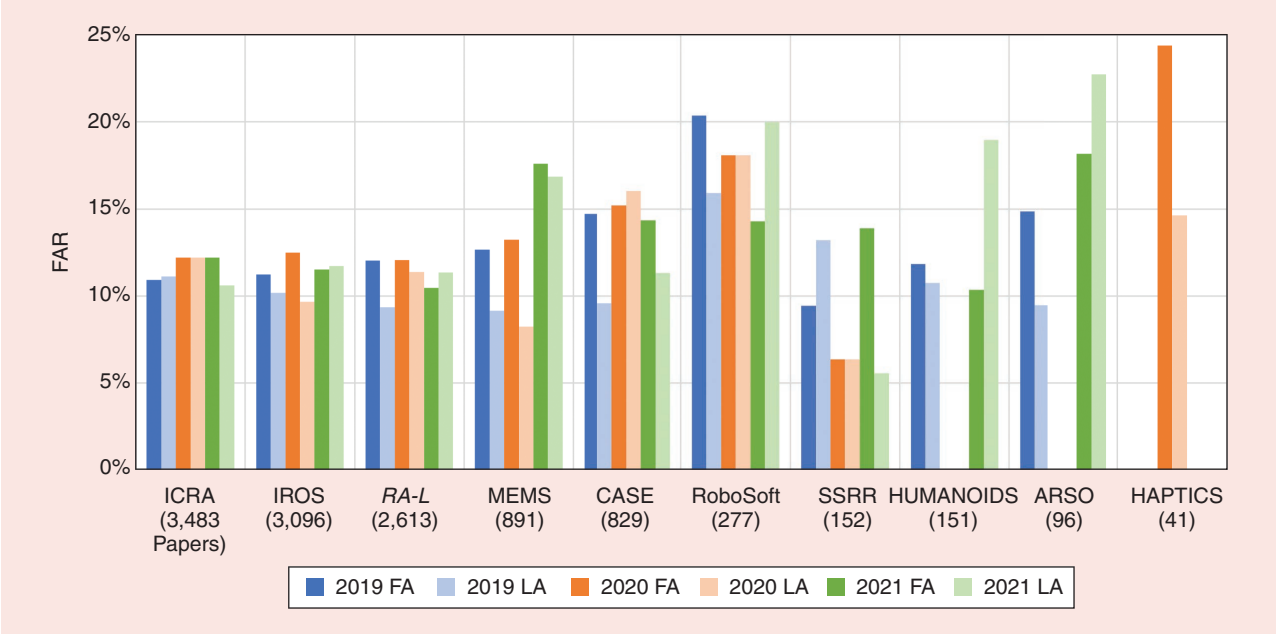

FIGURE 2. The FAR across the conferences and journal covered in this work. We find that the ratio is as low as 6% and as high as 24%, with an overall average of 11%–12%. FA: first author; LA: last author.

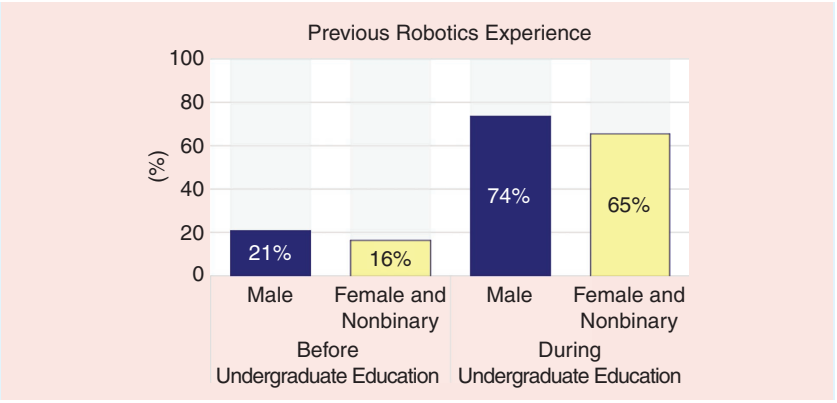

FIGURE 3. Survey respondents' first contact with robotics (n = 133, 41% female and nonbinary).

significant difference in the FAR between first and last authors.

Furthermore, we did not find any significant correlation between conference size and FAR. In fact, the lowest FAR and the highest FAR both came from relatively smaller conferences. Finally, as we counted authors multiple times when they appeared on more than one paper or article, we hypothesized that the distribution of the number of publications per author may have impacted these results. However, despite the fact that there were rare significant outliers (e.g., Daniela Rus and Masayuki Inaba had 63 and 74 last author publications, respectively), regardless of gender, 94%–95% of last authors and 99% of first authors produced three or fewer papers/articles. Consequently, this distribution had no significant effects.

DISCUSSION

Despite the many efforts to improve diversity, equity, and inclusion in the robotics community, including recent successful efforts to diversify gender in conference leadership [5], the overall robotics community remains not very gender diverse. This overall finding is, unfortunately, on par with many other CS and engineering subfields, as shown in Table 1, and is in line with or worse than additional recent studies into various other adjacent communities and particular conferences [8], [9], [10]. This only further reinforces the need to continue to push for improved diversity in robotics and CS and engineering more broadly.

> "THIS ONLY FURTHER REINFORCES THE NEED TO CONTINUE TO PUSH FOR IMPROVED DIVERSITY IN ROBOTICS AND CS AND ENGINEERING MORE BROADLY."

As a first attempt at trying to determine how to improve the diversity pipeline in robotics, we launched a survey in summer 2022 to the global robotics community advertised over various social media platforms and global robotics e-mail lists (e.g., robotics-worldwide). [This anonymous survey study was approved by the Institutional Review Board of Barnard College on 3 June 2022 (Approval 2122-0505-060).] As shown in Figure 3, results from our survey (n = 133, 41% female and nonbinary) indicate that, while most current robotics researchers, regardless of gender, did not experience robotics before their undergraduate education, they did experience robotics during their undergraduate education. While the sample size on the survey is quite small, and thus the results are very preliminary, we postulate that expanded opportunities for undergraduate robotics experiences—ranging from introductory courses, to clubs, to formal research opportunities—may be a strong lever for closing this gender gap and could be a potential path toward a more gender-diverse future for the robotics community. At the same time, we must also promote current efforts to bring science, technology, engineering, and mathematics (STEM) experiences—and, in particular, robotics experiences—into primary and secondary school classrooms. These earlier interventions will only further increase exposure to these topics, providing a potential launching pad for careers in robotics for a diverse cohort of students.

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