

A short methodological review on social robot navigation benchmarking

Pranup Chhetri¹, Alejandro Torrejón², Sergio Eslava² and Luis J. Manso¹

Abstract—Social Robot Navigation is the skill that allows robots to move efficiently in human-populated environments while ensuring safety, comfort, and trust. Unlike other areas of research, the scientific community has not yet achieved an agreement on how Social Robot Navigation should be benchmarked. This is notably important, as the lack of a *de facto* standard to benchmark Social Robot Navigation can hinder the progress of the field and may lead to contradicting conclusions. Motivated by this gap, we contribute with a short review focused exclusively on benchmarking trends in the period from January 2020 to July 2025. Of the 130 papers identified by our search using IEEE Xplore, we analysed the 85 papers that met the criteria of the review. This review addresses the metrics used in the literature for benchmarking purposes, the algorithms employed in such benchmarks, the use of human surveys for benchmarking, and how conclusions are drawn from the benchmarking results, when applicable.

I. INTRODUCTION

Benchmarking is key to providing evidence of the effectiveness of algorithms under equitable conditions. For instance, in object detection, metrics such as IoU [84] are essentially taken as a standard, allowing objective comparisons between different algorithms. Unlike computer vision, the Social Robot Navigation (SocNav) community has not yet reached an agreement on how SocNav algorithms should be benchmarked. This is, arguably, not due to lack of interest but due to the subjective nature of what *quality* means in the context of SocNav, and to the inherent complexity of human-robot interactions. Although, theoretically, in-situ surveys constitute one of the benchmarking approaches with strongest support from the research community, in practice, the time and operational costs of running significant and reproducible surveys frequently make them unfeasibly expensive [37].

The absence of a *de facto* standard benchmark for SocNav can hinder the progress of the field, as research can reach contradictory or flawed conclusions. Moreover, this absence can generate confusion for SocNav researchers, as it can be challenging to establish which algorithms their contributions should be compared against, which metrics should be used, and how to make a final decision whenever the metrics point in different directions. In light of the aforementioned situation, this review addresses the following research questions related to SocNav benchmarking:

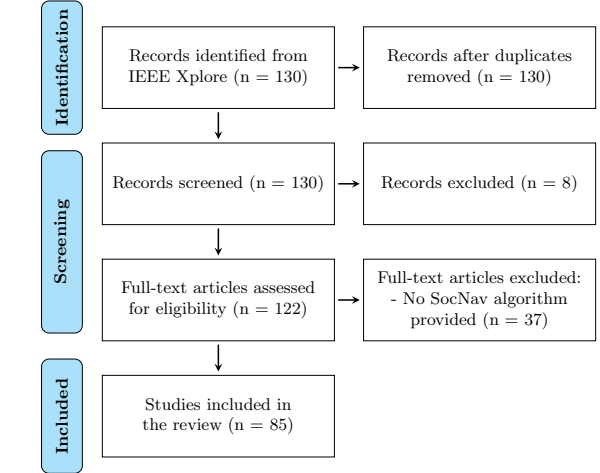


Fig. 1: PRISMA flow diagram of the process followed.

- 1) What metrics and algorithms are used?
- 2) How frequent are surveys involving human raters?
- 3) How are benchmarking results interpreted?

II. METHODOLOGY

Given that the purpose of this paper is to provide an overview of the latest trends in benchmarking SocNav algorithms rather than a fully-comprehensive review, the literature search was conducted exclusively on IEEE Xplore. Nevertheless, the methodology followed a structured approach to ensure reproducibility.

The search query used was ("*social robot navigation*" OR "*social navigation*"), and it was applied to the full text and metadata of the articles to maximise recall. Also in line with our goal of focusing on the current trends, the search was constrained to works published between January 2020 and July 2025, with all document types included (*i.e.*, conference and journal papers). The 130 papers returned by the search query were subjected to a two-stage screening process, as depicted in Fig. 1:

- Topic relevance: Despite matching the search query, some of the papers retrieved addressed SocNav tangentially and did not have it as their central focus. This constituted an exclusion criterion. Examples include works referring to SocNav as a necessary skill or an application area (*e.g.*, trajectory prediction). As a result, eight papers were discarded after manual inspection, leaving 122 papers.
- Algorithmic contribution: Of the remaining papers, 44 were excluded because they did not propose a **navigation algorithm**. After this second exclusion criterion, 85 papers were retained for review (65% of the total retrieved).

¹Pranup Chhetri and Luis J. Manso are with the Department of Artificial Intelligence and Robotics, Aston University, Aston Triangle, B47ET Birmingham, United Kingdom (l.manso@aston.ac.uk)

²Alejandro Torrejón and Sergio Eslava are with the Department of Computer and Communication Technology, Universidad de Extremadura, Avd. de la Universidad, 10001 Cáceres, Extremadura (atorrejon@unex.es, sergioeslava@unex.es)

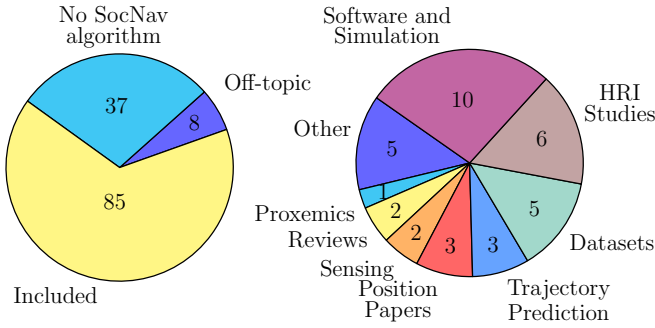


Fig. 2: On the left, an overview of the overall screening decisions. On the right, the distribution of the rationale for the application of the second exclusion criterion.

The screening was evenly distributed among the authors of the review, each paper being screened by two different members of the team to ensure consistent application of the criteria. In case of doubt or conflict, the team discussed the classification collectively.

The papers excluded after applying the second exclusion criterion were: HRI studies (6), datasets-only papers (5), position papers (3), reviews (2), or focused on other algorithmic topics other than robot control (44). The papers in this last category were categorised as: software & simulation (10), human trajectory prediction (3), sensing (3), proxemics (1), or other algorithmic questions (5, with only 1 item per category). The distribution of the reasons why papers were excluded is shown in Fig. 2.

Each of the final 85 papers that passed the criteria was reviewed to extract:

- the **quantitative** navigation metrics used,
- the algorithms used for **quantitative** benchmarking,
- the use of surveying **for benchmarking**, and
- how **conclusions** were extracted from the benchmarking process.

A. Further clarifications regarding metric selection

Metrics accounting for a phenomenon or its absence were considered equivalent (*e.g.*, ratio of missions with and without a collision). The same applied to metrics differing only by a threshold, such as Space Compliance (*SC*) and the Intimate Space Compliance.

Some works used weighted averages of metrics to circumvent the choice of a single metric. Although this can simplify comparisons, the weights were arbitrary in all instances encountered. In those cases, we considered the components rather than their weighted average.

Finally, metrics not directly related to navigation, such as perception or communication cues, were excluded.

B. Further clarifications regarding algorithm selection

Comparisons against pedestrian movement in a dataset or against a manually operated robot were also disregarded, as such comparisons depend on the specific pedestrian or operator's skills and do not establish a measurable property of a trajectory or algorithm. Similarly, ablations of a proposed

algorithm, and algorithms varying only in parameters (*e.g.*, the profile of social force models), were also considered as the same algorithm.

III. RESULTS

RQ1) What metrics and algorithms are used?

Of the 85 papers reviewed, 53 provided **quantitative metrics** for comparison against 3rd-party algorithms (62.4%), 17 (20%) reported quantitative results using metrics but no comparison against other algorithms, and 15 (17.6%) did not provide any quantitative results on navigation performance (some of these relied to human surveys). Overall, 66 papers (77.6%) used non-social metrics, 46 (54.1%) reported social metrics, and 40 (47.1%) used both types.

As for the rationale for metric selection, out of the 69 papers using any metric, 36 papers (52.2%) did not provide any rationale, 19 (27.5%) justified their choice (*e.g.*, based on good coverage of desired features), and 14 (20.3%) referred to the metrics selected being widely used, seen in previous literature, or used in a paper the authors built upon.

Regarding the rationale behind selecting algorithms for benchmarking, of the 53 papers comparing their performance against 3rd-party baselines, 4 (7.3%) chose based on similarity, 8 (15.1%) based on the papers they improved on, 7 (13.2%) based on popularity, 9 (16.4%) based on the papers being state-of-the-art, 3 (5.7%) based on subjective perception of quality, 3 (5.7%) followed choices made in previous literature, and 20 (35.8%) did not specify any rationale.

The metrics used for comparison, after the grouping as described in Sec II, are shown in Table I. The algorithms used for comparison are shown in Fig. 3, along with the papers and the metrics used in the comparisons.

RQ2) How frequent are surveys involving human raters?

Out of the 85 papers considered, 16 (18.9%) papers performed in-situ human-based surveys, but only 6 of these (7.1%) included alternative 3rd party algorithms for benchmarking purposes [94, 172, 115, 126, 52, 150]. The remaining 10 exclusively surveyed the performance of their own proposal. The most common questions asked in these surveys can be found in Table II.

RQ3) How are benchmarking results interpreted?

Out of 26 papers claiming better performance than the baselines used, 22 did so with either 2 or fewer metrics, or 2 or fewer algorithms, 3 of which used a single metric. Of the same 26, 5 used a single algorithm but multiple metrics; this can be considered a reasonable to claim better performance than a specific algorithm, but not necessarily state-of-the-art performance. Finally, 3 papers made claims that did not follow from the evidence provided.

A total of 14 papers claimed partial superiority, depending on the metrics and scenarios, and 3 papers claimed achieving results comparable but not necessarily surpassing SOTA performance.

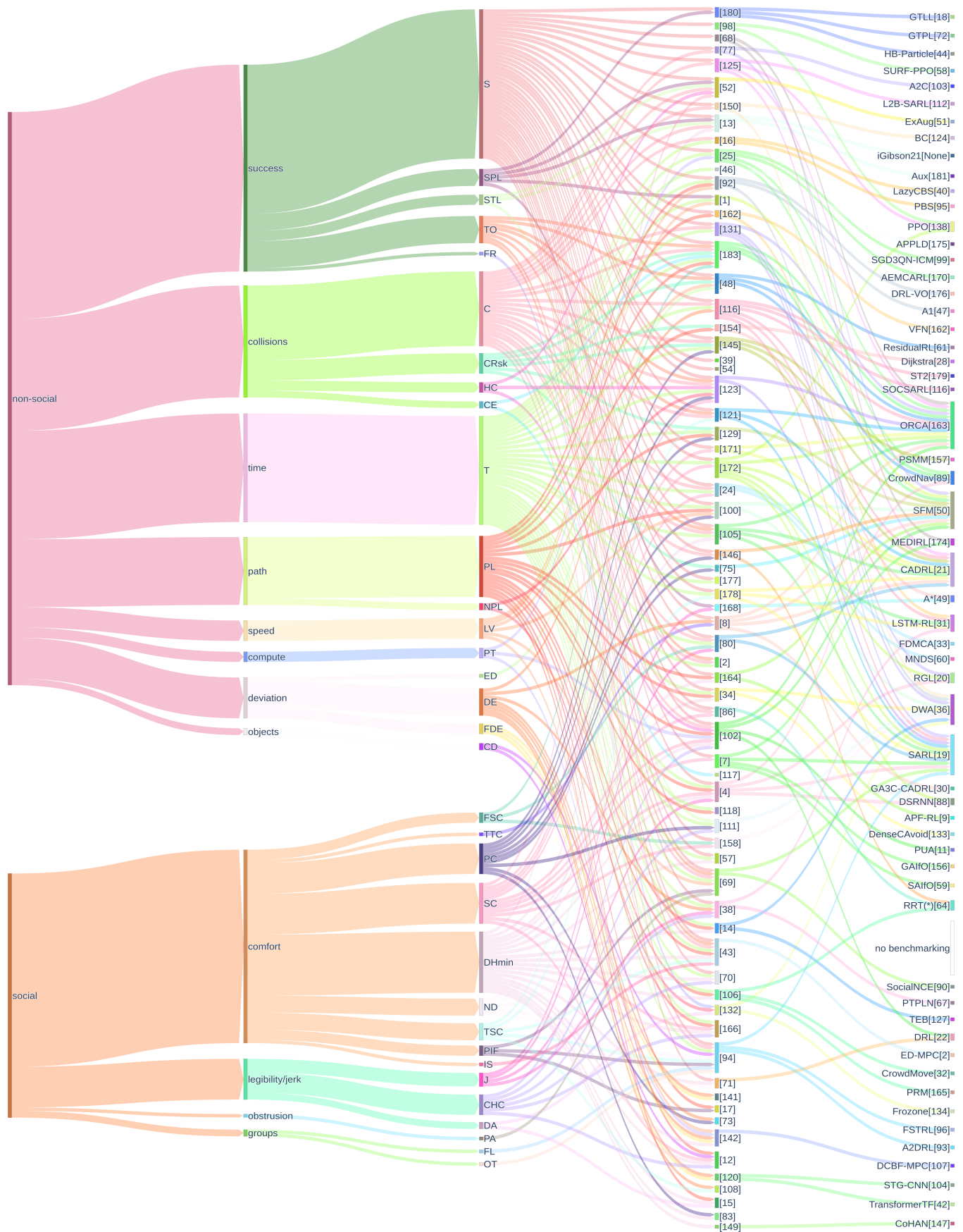


Fig. 3: Sankey diagram showing, left to right, a categorisation of metrics in social vs. non-social, the general variables measured by the metrics, the metrics found in the review, the works reviewed in this paper, and the baselines they used.

Short	Definition	Variable	Paper
C	Collision.	collision	[146]
CD	Clearing Distance from the robot to the closest object.	objects	[94]
CE	Collision Energy.	collision	[183]
CHC	Cumulative Heading Changes.	legibility	[96]
C_{risk}	Estimated risk of collision.	collision	[75]
DA	Deviation angle.	deviation	[132]
DE	Error between the target and actual trajectory.	deviation	[141]
DH_{min}	Minimum Distance to Humans.	comfort	[37]
ED	End Displacement over a threshold.	deviation	[48]
FDE	Final Displacement Error.	deviation	[141]
FL	Instances where a robot follows a group of pedestrians.	group	[94]
FR	Freezing Robot.	success	[132]
FSC	Full Space Compliance over a trajectory.	comfort	[183]
HC	Human Collisions.	collision	[123]
IS	Robot's speed when breaking Space Compliance.	comfort	[43]
J	The average change in acceleration per unit time.	legibility	[4]
LV	Linear Velocity.	speed	[69]
ND	Number of Discomfort instances.	comfort	[105]
NPL	Normalised Path Length — ratio between the path's length and the distance between the start and goal locations.	path	[132]
NT	Navigation Time.	time	[123]
OT	Number of instances where a robot overtakes a group of pedestrians.	group	[94]
PA	Average angular deviation between the pedestrians and their direct vector to their goal.	obtrusion	[69]
PC	Personal Space Cost.	comfort	[75]
PIF	Passes in Front of a moving human.	comfort	[17]
PL	Path Length.	path	[37]
PT	Planning Time.	compute	[142]
S	Success.	success	[183]
SC	Ratio of a trajectory in Space Compliance.	comfort	[37]
SPL	Success Weighted using normalised inverse path Length.	success	[37]
STL	Success Weighted by Time.	success	[111]
TO	Timeouts.	success	[123]
TSC	Time in adhering to Space Compliance.	comfort	[43]
TTC	Estimated Minimum Time to Collision if agents' speeds remain constant.	comfort	[11]

TABLE I: Short names and descriptions for the metrics identified following the methodology described in Sec. II. We provide a reference where the metric is used and, when possible, adopt the notation in [37].

Variable	Paper
Abruptness of the robot movement	[108]
Anxiety caused by the robot	[83]
Comfort or compliance	[37]
Adequacy of the perceived robot distance.	[83]
Awareness and movement adequacy w.r.t. groups.	[94]
Overall understanding of the robot's goals.	[152]
Likeability and friendliness	[74]
Naturalness and smoothness.	[78]
Overall navigation skills.	[108]
A robot's movement is easy to predict.	[108]
Perception of safety and risk	[37]
Adequacy of the robot's speed	[83]
Politeness and care about pedestrians.	[37]
The user's trust in the robot.	[17]
Unobtrusiveness.	[52]

TABLE II: Variables identified as surveyed in our review, accompanied by a reference where they have been used.

Finally, a set of 10 paper presented results with no superiority claims over the baselines, although they offered qualitative assessments of the results achieved, with respect to different metrics and/or scenarios.

Overall, 18 papers acknowledged the difficulty of achiev-

ing top performance across all metrics and argued for the need to achieve a balance: 11 of them referred to balancing efficiency and comfort [100, 48, 14, 13, 4, 71, 69, 86, 164, 123, 150], and 6 of them referred to the balance between efficiency and safety [4, 13, 105, 183, 1, 129].

IV. CONCLUSIONS

Despite the efforts of the Social Robot Navigation community, benchmarking protocols are still very heterogeneous, as can be graphically appreciated in Fig. 3. Although this is unsurprising when considering baselines (as new algorithms appear and older ones become obsolete), the inconsistency in the number and types of metrics used can be considered worrying. Using a high number of metrics can be difficult to interpret, redundant if there are highly-correlated metrics, and potentially lead to biased conclusions. However, a single metric linked to a single aspect (*e.g.*, S for success rate, or SC for space compliance), cannot capture the complexity of social robot navigation tasks. The number of metrics ranged from 1 (in 5 different instances) to 9 in [94]). Interestingly, 38 of the 85 papers reviewed, did not use any social navigation metric, and CrowdNav [89] was the only baseline created since 2020 that the papers reviewed used as a baseline.

Regarding **RQ1**: The 4 most common **social** metrics were DH_{min} , SC , PC , and C_{risk} . Authors frequently referred to the metrics being popular, or providing good coverage of properties when making their choices, although 52.2% did not provide a rationale. Most papers choose metrics such as PL or T over weighted metrics such as SPL or STL , which went against our expectations. The 4 most popular **non-social** metrics were S , T , C and PL , with similar justifications provided as for social metrics. The most common **baseline algorithms** used when benchmarking were ORCA [163], DWA [36], SFM [50], CADRL [21], SARL [19], CrowdNav [89] and LSTM-RL [31]. Authors frequently referred to their popularity, to their state-of-the-art status, and to baselines being the method they are improving when specifying why those were chosen—although 35.8% of papers did not specify any.

Regarding **RQ2**, 18.9% of the papers reviewed performed human-based surveying, but only 7.1% included 3rd party algorithms in their benchmarks.

Regarding **RQ3**, in most cases, papers an only claimed to have the best performance over all metrics and algorithms if the number of metrics and algorithms used for comparison were few. A considerable number of papers, 32.7%, referenced directly or indirectly to the difficulty of achieving best performance in all metrics, so most papers made their claim looking only at a subset of the metrics used, or referred to social variables being more important than efficiency-related metrics such as the navigation time T .

As a recommendation, to make benchmarking clearer, it can be beneficial to refrain from simply stating the framework used (*e.g.*, “ROS navigation stack”) when reporting results; explicitly mentioning the specific algorithm and configuration parameters can be much clearer for the readers.

REFERENCES

- [1] Sebastian Aegidius et al. “ASFM: Augmented Social Force Model for Legged Robot Social Navigation”. In: *2024 IEEE-RAS 23rd International Conference on Humanoid Robots (Humanoids)*. 2024 IEEE-RAS 23rd International Conference on Humanoid Robots (Humanoids). Nancy, France: IEEE, Nov. 22, 2024, pp. 37–44. DOI: 10 . 1109 / humanoid58906 . 2024 . 10769845. URL: <https://ieeexplore.ieee.org/document/10769845/> (visited on 07/14/2025).
- [2] Timur Akhtyamov et al. “Social robot navigation through constrained optimization: a comparative study of uncertainty-based objectives and constraints”. In: *European Conference on Mobile Robots*. IEEE. 2023, pp. 1–8.
- [3] Georgios Angelopoulos et al. “You Are In My Way: Non-verbal Social Cues for Legible Robot Navigation Behaviors”. In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Kyoto, Japan: IEEE, Oct. 23, 2022, pp. 657–662. DOI: 10 . 1109 / iros47612 . 2022 . 9981754. URL: <https://ieeexplore.ieee.org/document/9981754/> (visited on 07/14/2025).
- [4] Junaid Ahmed Ansari et al. “Exploring Social Motion Latent Space and Human Awareness for Effective Robot Navigation in Crowded Environments”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 1–8. DOI: 10 . 1109 / iros55552 . 2023 . 10341721. URL: <https://ieeexplore.ieee.org/document/10341721/> (visited on 07/14/2025).
- [5] Vasanth Reddy Baddam et al. “In Search of a Lost Metric: Human Empowerment as a Pillar of Socially Conscious Navigation”. In: *2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI). Melbourne, Australia: IEEE, Mar. 4, 2025, pp. 303–311. DOI: 10 . 1109 / hri61500 . 2025 . 10973894. URL: <https://ieeexplore.ieee.org/document/10973894/> (visited on 07/14/2025).
- [6] Bobak H Baghi et al. “Sesno: Sample efficient social navigation from observation”. In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2022, pp. 9164–9171.
- [7] Bobak H. Baghi et al. “SESNO: Sample Efficient Social Navigation from Observation”. In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Kyoto, Japan: IEEE, Oct. 23, 2022, pp. 9164–9171. DOI: 10 . 1109 / iros47612 . 2022 . 9981645. URL: <https://ieeexplore.ieee.org/document/9981645/> (visited on 07/14/2025).
- [8] Jean-Luc Bastarache, Christopher Nielsen, and Stephen L. Smith. “On Legible and Predictable Robot Navigation in Multi-Agent Environments”. In: *2023 IEEE International Conference on Robotics and Automation (ICRA)*. 2023 IEEE International Conference on Robotics and Automation (ICRA). London, United Kingdom: IEEE, May 29, 2023, pp. 5508–5514. DOI: 10 . 1109 / icra48891 . 2023 . 10160572. URL: <https://ieeexplore.ieee.org/document/10160572/> (visited on 07/14/2025).
- [9] Kemal Bektaş and H Işıl Bozma. “Apf-rl: Safe mapless navigation in unknown environments”. In: *2022 International Conference on Robotics and Automation (ICRA)*. IEEE. 2022, pp. 7299–7305.
- [10] Rashmi Bhaskara, Maurice Chiu, and Aniket Bera. “SG-LSTM: Social Group LSTM for Robot Navigation Through Dense Crowds”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 3835–3840. DOI: 10 . 1109 / iros55552 . 2023 . 10341954. URL: <https://ieeexplore.ieee.org/document/10341954/> (visited on 07/14/2025).
- [11] Abhijat Biswas et al. “Socnavbench: A grounded simulation testing framework for evaluating social navigation”. In: *ACM Transactions on Human-Robot Interaction (THRI)* 11.3 (2022), pp. 1–24.
- [12] Lv. Calderita et al. “Social Robot Navigation adapted to Time-dependent Affordance Spaces: a Use Case for Caregiving Centers”. In: *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Naples, Italy: IEEE, Aug. 2020, pp. 944–949. DOI: 10 . 1109 / ro-man47096 . 2020 . 9223514. URL: <https://ieeexplore.ieee.org/document/9223514/> (visited on 07/14/2025).
- [13] Enrico Cancelli et al. “Exploiting Proximity-Aware Tasks for Embodied Social Navigation”. In: *2023 IEEE/CVF International Conference on Computer Vision (ICCV)*. 2023 IEEE/CVF International Conference on Computer Vision (ICCV). Paris, France: IEEE, Oct. 1, 2023, pp. 10923–10933. DOI: 10 . 1109 / iccv51070 . 2023 . 01006. URL: <https://ieeexplore.ieee.org/document/10377162/> (visited on 07/14/2025).
- [14] Thanh Nguyen Canh, Xiem HoangVan, and Nak Young Chong. “Enhancing Social Robot Navigation

- tion with Integrated Motion Prediction and Trajectory Planning in Dynamic Human Environments”. In: *2024 24th International Conference on Control, Automation and Systems (ICCAS)*. 2024 24th International Conference on Control, Automation and Systems (ICCAS). Jeju, Korea, Republic of: IEEE, Oct. 29, 2024, pp. 731–736. DOI: 10.23919/iccas63016.2024.10773156. URL: <https://ieeexplore.ieee.org/document/10773156/> (visited on 07/14/2025).
- [15] Charlotte Cathcart et al. “Proactive Opinion-Driven Robot Navigation Around Human Movers”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 4052–4058. DOI: 10.1109/iros55552.2023.10341745. URL: <https://ieeexplore.ieee.org/document/10341745/> (visited on 07/14/2025).
- [16] Rohan Chandra et al. “SocialMapf: Optimal and Efficient Multi-Agent Path finding With Strategic Agents for Social Navigation”. In: *IEEE Robotics and Automation Letters* 8.6 (June 2023). Number: 6 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 3214–3221. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2023.3265169. URL: <https://ieeexplore.ieee.org/document/10093969/> (visited on 07/14/2025).
- [17] Yuhang Che, Allison M. Okamura, and Dorsa Sadigh. “Efficient and Trustworthy Social Navigation via Explicit and Implicit Robot-Human Communication”. In: *IEEE Transactions on Robotics* 36.3 (June 2020). Number: 3 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 692–707. ISSN: 1552-3098, 1941-0468. DOI: 10.1109/tro.2020.2964824. URL: <https://ieeexplore.ieee.org/document/8967120/> (visited on 07/14/2025).
- [18] Bao Xin Chen, Raghavender Sahdev, and John K Tsotsos. “Integrating stereo vision with a CNN tracker for a person-following robot”. In: *International Conference on Computer Vision Systems*. Springer. 2017, pp. 300–313.
- [19] Changan Chen et al. “Crowd-robot interaction: Crowd-aware robot navigation with attention-based deep reinforcement learning”. In: *International Conference on Robotics and Automation*. IEEE. 2019, pp. 6015–6022.
- [20] Changan Chen et al. “Relational graph learning for crowd navigation”. In: *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2020, pp. 10007–10013.
- [21] Yu Fan Chen et al. “Decentralized non-communicating multiagent collision avoidance with deep reinforcement learning”. In: *2017 IEEE international conference on robotics and automation (ICRA)*. IEEE. 2017, pp. 285–292.
- [22] Yu Fan Chen et al. “Socially aware motion planning with deep reinforcement learning”. In: *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2017, pp. 1343–1350.
- [23] Paco Chipana et al. “Gaussian-based Proxemic Zone Definition of Groups for Social Robot Navigation”. In: *2024 Latin American Robotics Symposium (LARS)*. 2024 Latin American Robotics Symposium (LARS). Arequipa, Peru: IEEE, Nov. 11, 2024, pp. 1–6. DOI: 10.1109/lars64411.2024.10786418. URL: <https://ieeexplore.ieee.org/document/10786418/> (visited on 07/14/2025).
- [24] Yuxiang Cui et al. “Learning World Transition Model for Socially Aware Robot Navigation”. In: *2021 IEEE International Conference on Robotics and Automation (ICRA)*. 2021 IEEE International Conference on Robotics and Automation (ICRA). Xi’an, China: IEEE, May 30, 2021, pp. 9262–9268. DOI: 10.1109/icra48506.2021.9561973. URL: <https://ieeexplore.ieee.org/document/9561973/> (visited on 07/14/2025).
- [25] Guido M. D’Amely Di Melendugno et al. “Hyp²Nav: Hyperbolic Planning and Curiosity for Crowd Navigation”. In: *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Abu Dhabi, United Arab Emirates: IEEE, Oct. 14, 2024, pp. 13023–13030. DOI: 10.1109/iros58592.2024.10801513. URL: <https://ieeexplore.ieee.org/document/10801513/> (visited on 07/14/2025).
- [26] Alex Day and Ioannis Karamouzas. “A Study in Zucker: Insights on Interactions Between Humans and Small Service Robots”. In: *IEEE Robotics and Automation Letters* 9.3 (Mar. 2024). Number: 3 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 2471–2478. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2024.3355641. URL: <https://ieeexplore.ieee.org/document/10404067/> (visited on 07/14/2025).
- [27] Tiago Rodrigues De Almeida et al. “THOR-MAGNI Act: Actions for Human Motion Modeling in Robot-Shared Industrial Spaces”. In: *2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI). Melbourne, Australia: IEEE, Mar. 4, 2025, pp. 1083–1087. DOI: 10.1109/hri61500.2025.10973897. URL: <https://ieeexplore.ieee.org/document/10973897/> (visited on 07/14/2025).

- ieee.org/document/10973897/ (visited on 07/14/2025).
- [28] Edsger W Dijkstra. "A note on two problems in connexion with graphs". In: *Edsger Wybe Dijkstra: his life, work, and legacy*. 2022, pp. 287–290.
- [29] Andrea Eirale, Matteo Leonetti, and Marcello Chiaberge. "Learning Social Cost Functions for Human-Aware Path Planning". In: *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Abu Dhabi, United Arab Emirates: IEEE, Oct. 14, 2024, pp. 5364–5371. DOI: 10.1109/iros58592.2024.10802768. URL: <https://ieeexplore.ieee.org/document/10802768/> (visited on 07/14/2025).
- [30] Michael Everett, Yu Fan Chen, and Jonathan P How. "Collision avoidance in pedestrian-rich environments with deep reinforcement learning". In: *Ieee Access* 9 (2021), pp. 10357–10377.
- [31] Michael Everett, Yu Fan Chen, and Jonathan P How. "Motion planning among dynamic, decision-making agents with deep reinforcement learning". In: *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2018, pp. 3052–3059.
- [32] Tingxiang Fan et al. "Crowdmov: Autonomous mapless navigation in crowded scenarios". In: *arXiv preprint arXiv:1807.07870* (2018).
- [33] Tingxiang Fan et al. "Fully distributed multi-robot collision avoidance via deep reinforcement learning for safe and efficient navigation in complex scenarios". In: *arXiv preprint arXiv:1808.03841* (2018).
- [34] Fang Fang et al. "A Unified Framework for Pedestrian Trajectory Prediction and Social-Friendly Navigation". In: *IEEE Transactions on Industrial Electronics* 71.9 (Sept. 2024). Number: 9 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 11072–11082. ISSN: 0278-0046, 1557-9948. DOI: 10.1109/tie.2023.3342301. URL: <https://ieeexplore.ieee.org/document/10372213/> (visited on 07/14/2025).
- [35] Anthony Favier, Phani Teja Singamaneni, and Rachid Alami. "An Intelligent Human Avatar to Debug and Challenge Human-aware Robot Navigation Systems". In: *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI). Sapporo, Japan: IEEE, Mar. 7, 2022, pp. 760–764. DOI: 10.1109/hri53351.2022.9889651. URL: <https://ieeexplore.ieee.org/document/9889651/> (visited on 07/14/2025).
- [36] Dieter Fox, Wolfram Burgard, and Sebastian Thrun. "The dynamic window approach to collision avoidance". In: *IEEE robotics & automation magazine* 4.1 (2002), pp. 23–33.
- [37] Anthony Francis et al. "Principles and Guidelines for Evaluating Social Robot Navigation Algorithms". In: *ACM Transactions on Human-Robot Interaction* 14.2 (2025), p. 65. DOI: 10.1145/3700599.
- [38] Hao Fu, Qiang Wang, and Haodong He. "Path-Following Navigation in Crowds With Deep Reinforcement Learning". In: *IEEE Internet of Things Journal* 11.11 (June 1, 2024). Number: 11 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 20236–20245. ISSN: 2327-4662, 2372-2541. DOI: 10.1109/jiot.2024.3370575. URL: <https://ieeexplore.ieee.org/document/10445747/> (visited on 07/14/2025).
- [39] Yusuke Fujioka, Yuyi Liu, and Takayuki Kanda. "I Need to Pass Through! Understandable Robot Behavior for Passing Interaction in Narrow Environment". In: *Proceedings of the 2024 ACM/IEEE International Conference on Human-Robot Interaction. HRI '24: ACM/IEEE International Conference on Human-Robot Interaction*. Boulder CO USA: ACM, Mar. 11, 2024, pp. 213–221. DOI: 10.1145/3610977.3634951. URL: <https://dl.acm.org/doi/10.1145/3610977.3634951> (visited on 07/14/2025).
- [40] Graeme Gange, Daniel Harabor, and Peter J Stuckey. "Lazy CBS: implicit conflict-based search using lazy clause generation". In: *Proceedings of the international conference on automated planning and scheduling*. Vol. 29. 2019, pp. 155–162.
- [41] Juan Carlos Garcia et al. "Towards the design of efficient and versatile cognitive robotic architecture based on distributed, low-latency working memory". In: *2022 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC)*. 2022 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC). Santa Maria da Feira, Portugal: IEEE, Apr. 29, 2022, pp. 9–14. DOI: 10.1109/icarsc55462.2022.9784798. URL: <https://ieeexplore.ieee.org/document/9784798/> (visited on 07/14/2025).
- [42] Francesco Giuliani et al. "Transformer networks for trajectory forecasting". In: *2020 25th international conference on pattern recognition (ICPR)*. IEEE. 2021, pp. 10335–10342.
- [43] Mahsa Golchoubian et al. "Uncertainty-Aware DRL for Autonomous Vehicle Crowd Navigation in Shared Space". In: *IEEE Transactions on Intelligent Vehicles* 9.12 (Dec. 2024). Number: 12 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 7931–7944. ISSN: 2379-8904, 2379-8858. DOI: 10.1109/tiv.2024.3405330. URL: <https://ieeexplore.ieee.org/document/10538404/> (visited on 07/14/2025).
- [44] Alex Goldhoorn et al. "Searching and tracking people in urban environments with static and dynamic

- obstacles”. In: *Robotics and Autonomous Systems* 98 (2017), pp. 147–157.
- [45] Elias Goldsztejn, Tal Feiner, and Ronen Brafman. “PTDRL: Parameter Tuning Using Deep Reinforcement Learning”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 11356–11362. DOI: 10.1109/iros55552.2023.10342140. URL: <https://ieeexplore.ieee.org/document/10342140/> (visited on 07/14/2025).
- [46] Elias Goldsztejn, Tal Feiner, and Ronen Brafman. “PTDRL: parameter tuning using deep reinforcement learning”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2023, pp. 11356–11362.
- [47] Ronja Guldenring et al. “Learning local planners for human-aware navigation in indoor environments”. In: *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2020, pp. 6053–6060.
- [48] James R. Han et al. “DR-MPC: Deep Residual Model Predictive Control for Real-World Social Navigation”. In: *IEEE Robotics and Automation Letters* 10.4 (Apr. 2025). Number: 4 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 4029–4036. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2025.3546106. URL: <https://ieeexplore.ieee.org/document/10904316/> (visited on 07/14/2025).
- [49] Peter E Hart, Nils J Nilsson, and Bertram Raphael. “A formal basis for the heuristic determination of minimum cost paths”. In: *IEEE transactions on Systems Science and Cybernetics* 4.2 (1968), pp. 100–107.
- [50] Dirk Helbing and Peter Molnar. “Social force model for pedestrian dynamics”. In: *Physical review E* 51.5 (1995), p. 4282.
- [51] Noriaki Hirose et al. “Exaug: Robot-conditioned navigation policies via geometric experience augmentation”. In: *arXiv preprint arXiv:2210.07450* (2022).
- [52] Noriaki Hirose et al. “SACSoN: Scalable Autonomous Control for Social Navigation”. In: *IEEE Robotics and Automation Letters* 9.1 (Jan. 2024). Number: 1 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 49–56. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2023.3329626. URL: <https://ieeexplore.ieee.org/document/10305270/> (visited on 07/14/2025).
- [53] Simon Holk, Daniel Marta, and Iolanda Leite. “POLITE: Preferences Combined with Highlights in Reinforcement Learning”. In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 2288–2295. DOI: 10.1109/icra57147.2024.10610505. URL: <https://ieeexplore.ieee.org/document/10610505/> (visited on 07/14/2025).
- [54] Simon Holk, Daniel Marta, and Iolanda Leite. “PREDILECT: Preferences Delineated with Zero-Shot Language-based Reasoning in Reinforcement Learning”. In: *Proceedings of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*. HRI ’24: ACM/IEEE International Conference on Human-Robot Interaction. Boulder CO USA: ACM, Mar. 11, 2024, pp. 259–268. DOI: 10.1145/3610977.3634970. URL: <https://dl.acm.org/doi/10.1145/3610977.3634970> (visited on 07/14/2025).
- [55] Blake Holman et al. “Watch Where You’re Going! Gaze and Head Orientation as Predictors for Social Robot Navigation”. In: *2021 IEEE International Conference on Robotics and Automation (ICRA)*. 2021 IEEE International Conference on Robotics and Automation (ICRA). Xi’an, China: IEEE, May 30, 2021, pp. 3553–3559. DOI: 10.1109/icra48506.2021.9561286. URL: <https://ieeexplore.ieee.org/document/9561286/> (visited on 07/14/2025).
- [56] Jarrett Holtz and Joydeep Biswas. “SocialGym: A Framework for Benchmarking Social Robot Navigation”. In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Kyoto, Japan: IEEE, Oct. 23, 2022, pp. 11246–11252. DOI: 10.1109/iros47612.2022.9982021. URL: <https://ieeexplore.ieee.org/document/9982021/> (visited on 07/14/2025).
- [57] Jarrett Holtz et al. “Iterative Program Synthesis for Adaptable Social Navigation”. In: *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Prague, Czech Republic: IEEE, Sept. 27, 2021, pp. 6256–6261. DOI: 10.1109/iros51168.2021.9636540. URL: <https://ieeexplore.ieee.org/document/9636540/> (visited on 07/14/2025).
- [58] Zhimin Hou et al. “Off-policy maximum entropy reinforcement learning: Soft actor-critic with advantage weighted mixture policy (sac-awmp)”. In: *arXiv preprint arXiv:2002.02829* (2020).
- [59] Eddy Hudson, Garrett Warnell, and Peter Stone. “Rail: A modular framework for reinforcement-learning-based adversarial imitation learning”. In: *arXiv preprint arXiv:2105.03756* (2021).
- [60] Jun Jin et al. “Mapless navigation among dynamics with social-safety-awareness: a reinforcement learning approach from 2d laser scans”. In: *2020 IEEE*

- international conference on robotics and automation (ICRA)*. IEEE. 2020, pp. 6979–6985.
- [61] Tobias Johannink et al. “Residual reinforcement learning for robot control”. In: *2019 international conference on robotics and automation (ICRA)*. IEEE. 2019, pp. 6023–6029.
- [62] Aditya Kapoor et al. “SocNavGym: A Reinforcement Learning Gym for Social Navigation”. In: *2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Busan, Korea, Republic of: IEEE, Aug. 28, 2023, pp. 2010–2017. DOI: 10.1109/ro-man57019.2023.10309591. URL: <https://ieeexplore.ieee.org/document/10309591/> (visited on 07/14/2025).
- [63] Kristofer Kappel and Paulo R. Ferreira. “Towards Comfortable and Socially Acceptable Navigation in Autonomous Motorized Wheelchairs”. In: *2023 Latin American Robotics Symposium (LARS), 2023 Brazilian Symposium on Robotics (SBR), and 2023 Workshop on Robotics in Education (WRE)*. 2023 Latin American Robotics Symposium (LARS), 2023 Brazilian Symposium on Robotics (SBR), and 2023 Workshop on Robotics in Education (WRE). Salvador, Brazil: IEEE, Oct. 9, 2023, pp. 319–324. DOI: 10.1109/lars/sbr/wre59448.2023.10332989. URL: <https://ieeexplore.ieee.org/document/10332989/> (visited on 07/14/2025).
- [64] Sertac Karaman and Emilio Frazzoli. “Sampling-based algorithms for optimal motion planning”. In: *The international journal of robotics research* 30.7 (2011), pp. 846–894.
- [65] Haresh Karnan et al. “Socially CompliAnt Navigation Dataset (SCAND): A Large-Scale Dataset of Demonstrations for Social Navigation”. In: *IEEE Robotics and Automation Letters* 7.4 (Oct. 2022). Number: 4 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 11807–11814. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2022.3184025. URL: <https://ieeexplore.ieee.org/document/9799755/> (visited on 07/14/2025).
- [66] Jaroslaw Karwowski and Wojciech Szynkiewicz. “SRPB: a benchmark for the quantitative evaluation of a social robot navigation”. In: *2023 27th International Conference on Methods and Models in Automation and Robotics (MMAR)*. 2023 27th International Conference on Methods and Models in Automation and Robotics (MMAR). Miedzyzdroje, Poland: IEEE, Aug. 22, 2023, pp. 411–416. DOI: 10.1109/mmar58394.2023.10242422. URL: <https://ieeexplore.ieee.org/document/10242422/> (visited on 07/14/2025).
- [67] Linh Kästner et al. “Obstacle-aware waypoint generation for long-range guidance of deep-reinforcement-learning-based navigation approaches”. In: *arXiv preprint arXiv:2109.11639* (2021).
- [68] Tribhi Kathuria et al. “Learning Implicit Social Navigation Behavior Using Deep Inverse Reinforcement Learning”. In: *IEEE Robotics and Automation Letters* 10.5 (May 2025). Number: 5 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 5146–5153. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2025.3557299. URL: <https://ieeexplore.ieee.org/document/10947583/> (visited on 07/14/2025).
- [69] Kapil Katyal et al. “Learning a Group-Aware Policy for Robot Navigation”. In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Kyoto, Japan: IEEE, Oct. 23, 2022, pp. 11328–11335. DOI: 10.1109/iros47612.2022.9981183. URL: <https://ieeexplore.ieee.org/document/9981183/> (visited on 07/14/2025).
- [70] Leonid Keselman et al. “Optimizing Algorithms from Pairwise User Preferences”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 4161–4167. DOI: 10.1109/iros55552.2023.10342081. URL: <https://ieeexplore.ieee.org/document/10342081/> (visited on 07/14/2025).
- [71] Mincheul Kim, Youngsun Kwon, and Sung-Eui Yoon. “Group Estimation for Social Robot Navigation in Crowded Environments”. In: *2022 22nd International Conference on Control, Automation and Systems (ICCAS)*. 2022 22nd International Conference on Control, Automation and Systems (ICCAS). Jeju, Korea, Republic of: IEEE, Nov. 27, 2022, pp. 1421–1425. DOI: 10.23919/iccas55662.2022.10003761. URL: <https://ieeexplore.ieee.org/document/10003761/> (visited on 07/14/2025).
- [72] Minkyu Kim et al. “An architecture for person-following using active target search”. In: *arXiv preprint arXiv:1809.08793* (2018).
- [73] Stefan H. Kiss et al. “Probabilistic Dynamic Crowd Prediction for Social Navigation”. In: *2021 IEEE International Conference on Robotics and Automation (ICRA)*. 2021 IEEE International Conference on Robotics and Automation (ICRA). Xi’an, China: IEEE, May 30, 2021, pp. 9269–9275. DOI: 10.1109/icra48506.2021.9561053. URL: <https://ieeexplore.ieee.org/document/9561053/> (visited on 07/14/2025).
- [74] Ryo Kitagawa, Yuyi Liu, and Takayuki Kanda. “Human-inspired Motion Planning for Omni-

- directional Social Robots”. In: *Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*. HRI '21: ACM/IEEE International Conference on Human-Robot Interaction. Boulder CO USA: ACM, Mar. 8, 2021, pp. 34–42. DOI: 10.1145/3434073.3444679. URL: <https://dl.acm.org/doi/10.1145/3434073.3444679> (visited on 07/14/2025).
- [75] Hasan Kivrak et al. “A multilevel mapping based pedestrian model for social robot navigation tasks in unknown human environments”. In: *2020 International Conference on INnovations in Intelligent SysTems and Applications (INISTA)*. 2020 International Conference on INnovations in Intelligent SysTems and Applications (INISTA). Novi Sad, Serbia: IEEE, Aug. 2020, pp. 1–7. DOI: 10.1109/inista49547.2020.9194617. URL: <https://ieeexplore.ieee.org/document/9194617/> (visited on 07/14/2025).
- [76] Hasan Kivrak et al. “Physiological Data-Based Evaluation of a Social Robot Navigation System”. In: *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Naples, Italy: IEEE, Aug. 2020, pp. 994–999. DOI: 10.1109/ro-man47096.2020.9223539. URL: <https://ieeexplore.ieee.org/document/9223539/> (visited on 07/14/2025).
- [77] Abhisek Konar, Bobak H. Baghi, and Gregory Dudek. “Learning Goal Conditioned Socially Compliant Navigation From Demonstration Using Risk-Based Features”. In: *IEEE Robotics and Automation Letters* 6.2 (Apr. 2021). Number: 2 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 651–658. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2020.3048657. URL: <https://ieeexplore.ieee.org/document/9312388/> (visited on 07/14/2025).
- [78] Thibault Kruse et al. “Human-aware robot navigation: A survey”. In: *Robotics and Autonomous Systems* 61.12 (2013), pp. 1726–1743.
- [79] I-Hsiang Lai and Wei-Liang Lin. “Autonomous Mover with Social Distance Respect”. In: *2022 IEEE International Conference on Recent Advances in Systems Science and Engineering (RASSE)*. 2022 IEEE International Conference on Recent Advances in Systems Science and Engineering (RASSE). Tainan, Taiwan: IEEE, Nov. 7, 2022, pp. 1–4. DOI: 10.1109/rasse54974.2022.9989723. URL: <https://ieeexplore.ieee.org/document/9989723/> (visited on 07/14/2025).
- [80] Viet-Anh Le et al. “Social Navigation in Crowded Environments with Model Predictive Control and Deep Learning-Based Human Trajectory Prediction”. In: *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Abu Dhabi, United Arab Emirates: IEEE, Oct. 14, 2024, pp. 4793–4799. DOI: 10.1109/iro558592.2024.10802371. URL: <https://ieeexplore.ieee.org/document/10802371/> (visited on 07/14/2025).
- [81] Minh Lee et al. “Dynamic Multi-Object Analysis Using Particles for Social Navigation”. In: *2024 24th International Conference on Control, Automation and Systems (ICCAS)*. 2024 24th International Conference on Control, Automation and Systems (ICCAS). Jeju, Korea, Republic of: IEEE, Oct. 29, 2024, pp. 922–926. DOI: 10.23919/iccas63016.2024.10773378. URL: <https://ieeexplore.ieee.org/document/10773378/> (visited on 07/14/2025).
- [82] Fabio Almeida Leite et al. “A Robocentric Paradigm for Enhanced Social Navigation in Autonomous Robotic: a use case for an autonomous Wheelchair”. In: *2024 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC)*. 2024 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC). Paredes de Coura, Portugal: IEEE, May 2, 2024, pp. 112–119. DOI: 10.1109/icarsc61747.2024.10535955. URL: <https://ieeexplore.ieee.org/document/10535955/> (visited on 07/14/2025).
- [83] Benjamin Lewandowski et al. “Socially Compliant Human-Robot Interaction for Autonomously Scanning Tasks in Supermarket Environments”. In: *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Naples, Italy: IEEE, Aug. 2020, pp. 363–370. DOI: 10.1109/ro-man47096.2020.9223568. URL: <https://ieeexplore.ieee.org/document/9223568/> (visited on 07/14/2025).
- [84] Tsung-Yi Lin et al. “Microsoft COCO: Common objects in context”. In: *European conference on computer vision*. Springer. 2014, pp. 740–755.
- [85] Alexis Linard et al. “Formalizing Trajectories in Human-Robot Encounters via Probabilistic STL Inference”. In: *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Prague, Czech Republic: IEEE, Sept. 27, 2021. DOI: 10.1109/iro51168.2021.9635951. URL: <https://ieeexplore.ieee.org/document/9635951/> (visited on 07/14/2025).
- [86] Alexis Linard et al. “Real-Time RRT* with Signal Temporal Logic Preferences”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).

- ference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 8621–8627. DOI: 10.1109/iros55552.2023.10341993. URL: <https://ieeexplore.ieee.org/document/10341993/> (visited on 07/14/2025).
- [87] Bo Ling et al. “SocialGAIL: Faithful Crowd Simulation for Social Robot Navigation”. In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 16873–16880. DOI: 10.1109/icra57147.2024.10610371. URL: <https://ieeexplore.ieee.org/document/10610371/> (visited on 07/14/2025).
- [88] Shuijing Liu et al. “Decentralized structural-rnn for robot crowd navigation with deep reinforcement learning”. In: *2021 IEEE international conference on robotics and automation (ICRA)*. IEEE. 2021, pp. 3517–3524.
- [89] Shuijing Liu et al. “Intention aware robot crowd navigation with attention-based interaction graph”. In: *arXiv preprint arXiv:2203.01821* (2022).
- [90] Yuejiang Liu, Qi Yan, and Alexandre Alahi. “Social NCE: Contrastive learning of socially-aware motion representations”. In: *Proceedings of the IEEE/CVF International Conference on Computer Vision*. 2021, pp. 15118–15129.
- [91] Shih-Yun Lo, Elaine Schaertl Short, and Andrea L. Thomaz. “Planning with Partner Uncertainty Modeling for Efficient Information Revealing in Teamwork”. In: *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. HRI ’20: ACM/IEEE International Conference on Human-Robot Interaction. Cambridge United Kingdom: ACM, Mar. 9, 2020, pp. 319–327. DOI: 10.1145/3319502.3374827. URL: <https://dl.acm.org/doi/10.1145/3319502.3374827> (visited on 07/14/2025).
- [92] Siyi Lu et al. “SocialNav-FTI: field-Theory-Inspired Social-aware Navigation Framework based on Human Behavior and Social Norms”. In: *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Abu Dhabi, United Arab Emirates: IEEE, Oct. 14, 2024, pp. 4808–4815. DOI: 10.1109/iros58592.2024.10802269. URL: <https://ieeexplore.ieee.org/document/10802269/> (visited on 07/14/2025).
- [93] Xiaojun Lu et al. “All aware robot navigation in human environments using deep reinforcement learning”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2023, pp. 5989–5996.
- [94] Xiaojun Lu et al. “Group-Aware Robot Navigation in Crowds Using Spatio-Temporal Graph Attention Network With Deep Reinforcement Learning”. In: *IEEE Robotics and Automation Letters* 10.4 (Apr. 2025). Number: 4 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 4140–4147. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2025.3549663. URL: <https://ieeexplore.ieee.org/document/10918817/> (visited on 07/14/2025).
- [95] Hang Ma et al. “Searching with consistent prioritization for multi-agent path finding”. In: *Proceedings of the AAAI conference on artificial intelligence*. Vol. 33. 01. 2019, pp. 7643–7650.
- [96] Tao Ma et al. “A spatiotemporal graphical attention navigation algorithm based on limited state information”. In: *IEEE Transactions on Computational Social Systems* 11.5 (2024), pp. 6407–6421.
- [97] Daniel Marta et al. “Aligning Human Preferences with Baseline Objectives in Reinforcement Learning”. In: *2023 IEEE International Conference on Robotics and Automation (ICRA)*. 2023 IEEE International Conference on Robotics and Automation (ICRA). London, United Kingdom: IEEE, May 29, 2023, pp. 7562–7568. DOI: 10.1109/icra48891.2023.10161261. URL: <https://ieeexplore.ieee.org/document/10161261/> (visited on 07/14/2025).
- [98] Daniel Marta et al. “SEQUEL: Semi-Supervised Preference-based RL with Query Synthesis via Latent Interpolation”. In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 9585–9592. DOI: 10.1109/icra57147.2024.10610534. URL: <https://ieeexplore.ieee.org/document/10610534/> (visited on 07/14/2025).
- [99] Diego Martinez-Baselga, Luis Riazuelo, and Luis Montano. “Improving robot navigation in crowded environments using intrinsic rewards”. In: *arXiv preprint arXiv:2302.06554* (2023).
- [100] Mauro Martini et al. “Adaptive Social Force Window Planner with Reinforcement Learning”. In: *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Abu Dhabi, United Arab Emirates: IEEE, Oct. 14, 2024, pp. 4816–4822. DOI: 10.1109/iros58592.2024.10802383. URL: <https://ieeexplore.ieee.org/document/10802383/> (visited on 07/14/2025).
- [101] Kenechukwu C. Mbanisi, Michael Gennert, and Zhi Li. “SocNavAssist: A Haptic Shared Autonomy Framework for Social Navigation Assistance of Mobile Telepresence Robots”. In: *2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS)*. 2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS).

- Magdeburg, Germany: IEEE, Sept. 8, 2021, pp. 1–3. DOI: 10.1109/ichms53169.2021.9582637. URL: <https://ieeexplore.ieee.org/document/9582637/> (visited on 07/14/2025).
- [102] Carlos Medina-Sánchez et al. “Human-Aware Navigation in Crowded Environments Using Adaptive Proxemic Area and Group Detection”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 6741–6748. DOI: 10.1109/iros55552.2023.10342385. URL: <https://ieeexplore.ieee.org/document/10342385/> (visited on 07/14/2025).
- [103] Volodymyr Mnih et al. “Asynchronous methods for deep reinforcement learning”. In: *International conference on machine learning*. PmLR. 2016, pp. 1928–1937.
- [104] Abdualлах Mohamed et al. “Social-stgcnn: A social spatio-temporal graph convolutional neural network for human trajectory prediction”. In: *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*. 2020, pp. 14424–14432.
- [105] Syed Muhammad Mustafa et al. “Context Aware Mamba-based Reinforcement Learning for Social Robot Navigation”. In: *2024 12th International Conference on Control, Mechatronics and Automation (ICCMA)*. 2024 12th International Conference on Control, Mechatronics and Automation (ICCMA). London, United Kingdom: IEEE, Nov. 11, 2024, pp. 154–159. DOI: 10.1109/iccma63715.2024.10843924. URL: <https://ieeexplore.ieee.org/document/10843924/> (visited on 07/14/2025).
- [106] Venkatraman Narayanan et al. “EWAwareNet: Emotion-Aware Pedestrian Intent Prediction and Adaptive Spatial Profile Fusion for Social Robot Navigation”. In: *2023 IEEE International Conference on Robotics and Automation (ICRA)*. 2023 IEEE International Conference on Robotics and Automation (ICRA). London, United Kingdom: IEEE, May 29, 2023, pp. 7569–7575. DOI: 10.1109/icra48891.2023.10161504. URL: <https://ieeexplore.ieee.org/document/10161504/> (visited on 07/14/2025).
- [107] Kunal S Narkhede et al. “A sequential mpc approach to reactive planning for bipedal robots using safe corridors in highly cluttered environments”. In: *IEEE Robotics and Automation Letters* 7.4 (2022), pp. 11831–11838.
- [108] Ingrid Navarro et al. “SoRTS: Learned Tree Search for Long Horizon Social Robot Navigation”. In: *IEEE Robotics and Automation Letters* 9.4 (Apr. 2024). Number: 4 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 3759–3766. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2024.3370051. URL: <https://ieeexplore.ieee.org/document/10449372/> (visited on 07/14/2025).
- [109] Margot M.E. Neggers et al. “Effect of Robot Gazing Behavior on Human Comfort and Robot Predictability in Navigation”. In: *2022 IEEE International Conference on Advanced Robotics and Its Social Impacts (ARSO)*. 2022 IEEE International Conference on Advanced Robotics and Its Social Impacts (ARSO). Long Beach, CA, USA: IEEE, May 28, 2022, pp. 1–6. DOI: 10.1109/arso54254.2022.9802975. URL: <https://ieeexplore.ieee.org/document/9802975/> (visited on 07/14/2025).
- [110] Duc M. Nguyen et al. “Toward Human-Like Social Robot Navigation: A Large-Scale, Multi-Modal, Social Human Navigation Dataset”. In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023. DOI: 10.1109/iros55552.2023.10342447. URL: <https://ieeexplore.ieee.org/document/10342447/> (visited on 07/14/2025).
- [111] Trung-Tin Nguyen and Trung Dung Ngo. “Spatiotemporal Motion Profiles for Cost-Based Optimal Approaching Pose Estimation”. In: *2024 IEEE/SICE International Symposium on System Integration (SII)*. 2024 IEEE/SICE International Symposium on System Integration (SII). Ha Long, Vietnam: IEEE, Jan. 8, 2024, pp. 92–98. DOI: 10.1109/sii58957.2024.10417396. URL: <https://ieeexplore.ieee.org/document/10417396/> (visited on 07/14/2025).
- [112] Mai Nishimura and Ryo Yonetani. “L2b: Learning to balance the safety-efficiency trade-off in interactive crowd-aware robot navigation”. In: *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2020, pp. 11004–11010.
- [113] Leonardo Costa Nogueira, Plinio Thomaz Aquino, and Flavio Tonidandel. “Legibility on Social Robot Navigation: A Survey”. In: *2025 Brazilian Conference on Robotics (CROS)*. 2025 Brazilian Conference on Robotics (CROS). Belo Horizonte, Brazil: IEEE, Apr. 28, 2025, pp. 1–6. DOI: 10.1109/cros66186.2025.11066134. URL: <https://ieeexplore.ieee.org/document/11066134/> (visited on 07/14/2025).
- [114] Iaroslav Okunevich et al. “Human-centered Benchmarking for Socially-Compliant Robot Navigation”. In: *2023 European Conference on Mobile Robots (ECMR)*. 2023 European Conference on Mobile Robots (ECMR). Coimbra, Portugal: IEEE, Sept. 4, 2023, pp. 1–7. DOI: 10.1109/ecmr59166.2023.10256378. URL: <https://ieeexplore.ieee.org/document/10256378/> (visited on 07/14/2025).

- [115] Iaroslav Okunevich et al. "Online Context Learning for Socially Compliant Navigation". In: *IEEE Robotics and Automation Letters* (2025).
- [116] Iaroslav Okunevich et al. "Online Context Learning for Socially Compliant Navigation". In: *IEEE Robotics and Automation Letters* 10.5 (May 2025). Number: 5 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 5042–5049. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2025.3557309. URL: <https://ieeexplore.ieee.org/document/10947499/> (visited on 07/14/2025).
- [117] Diego Paez-Granados, Vaibhav Gupta, and Aude Billard. "Unfreezing Social Navigation: Dynamical Systems based Compliance for Contact Control in Robot Navigation". In: *2022 International Conference on Robotics and Automation (ICRA)*. 2022 IEEE International Conference on Robotics and Automation (ICRA). Philadelphia, PA, USA: IEEE, May 23, 2022, pp. 8368–8374. DOI: 10.1109/icra46639.2022.9811772. URL: <https://ieeexplore.ieee.org/document/9811772/> (visited on 07/14/2025).
- [118] Heung-Min Park, Donghwi Jung, and Seong-Woo Kim. "Semi-Communicate Social Navigation using Deep Q Networks". In: *2022 International Conference on Electronics, Information, and Communication (ICEIC)*. 2022 International Conference on Electronics, Information, and Communication (ICEIC). Jeju, Korea, Republic of: IEEE, Feb. 6, 2022, pp. 1–3. DOI: 10.1109/iceic54506.2022.9748263. URL: <https://ieeexplore.ieee.org/document/9748263/> (visited on 07/14/2025).
- [119] Jay Patrikar et al. "Predicting Like A Pilot: Dataset and Method to Predict Socially-Aware Aircraft Trajectories in Non-Towered Terminal Airspace". In: *2022 International Conference on Robotics and Automation (ICRA)*. 2022 IEEE International Conference on Robotics and Automation (ICRA). Philadelphia, PA, USA: IEEE, May 23, 2022, pp. 2525–2531. DOI: 10.1109/icra46639.2022.9811972. URL: <https://ieeexplore.ieee.org/document/9811972/> (visited on 07/14/2025).
- [120] Jay Patrikar et al. "Predicting like a pilot: Dataset and method to predict socially-aware aircraft trajectories in non-towered terminal airspace". In: *2022 international conference on robotics and automation (icra)*. IEEE. 2022, pp. 2525–2531.
- [121] Claudia Perez-D'Arpino et al. "Robot Navigation in Constrained Pedestrian Environments using Reinforcement Learning". In: *2021 IEEE International Conference on Robotics and Automation (ICRA)*. 2021 IEEE International Conference on Robotics and Automation (ICRA). Xi'an, China: IEEE, May 30, 2021, pp. 1140–1146. DOI: 10.1109/icra48506.2021.9560893. URL: <https://ieeexplore.ieee.org/document/9560893/> (visited on 07/14/2025).
- [122] Noé Pérez-Higueras et al. "HuNavSim: A ROS 2 Human Navigation Simulator for Benchmarking Human-Aware Robot Navigation". In: *IEEE Robotics and Automation Letters* 8.11 (Nov. 2023). Number: 11 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 7130–7137. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2023.3316072. URL: <https://ieeexplore.ieee.org/document/10252030/> (visited on 07/14/2025).
- [123] Sara Pohland et al. "Stranger Danger! Identifying and Avoiding Unpredictable Pedestrians in RL-based Social Robot Navigation". In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 15217–15224. DOI: 10.1109/icra57147.2024.10610413. URL: <https://ieeexplore.ieee.org/document/10610413/> (visited on 07/14/2025).
- [124] Dean A Pomerleau. "Alvin: An autonomous land vehicle in a neural network". In: *Advances in neural information processing systems* 1 (1988).
- [125] Quecheng Qiu et al. "Learning to Socially Navigate in Pedestrian-rich Environments with Interaction Capacity". In: *2022 International Conference on Robotics and Automation (ICRA)*. 2022 IEEE International Conference on Robotics and Automation (ICRA). Philadelphia, PA, USA: IEEE, May 23, 2022, pp. 279–285. DOI: 10.1109/icra46639.2022.9811662. URL: <https://ieeexplore.ieee.org/document/9811662/> (visited on 07/14/2025).
- [126] Amir Hossain Raj et al. "Rethinking Social Robot Navigation: Leveraging the Best of Two Worlds". In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 16330–16337. DOI: 10.1109/icra57147.2024.10611710. URL: <https://ieeexplore.ieee.org/document/10611710/> (visited on 07/14/2025).
- [127] Christoph Rösmann, Frank Hoffmann, and Torsten Bertram. "Timed-elastic-bands for time-optimal point-to-point nonlinear model predictive control". In: *2015 european control conference (ECC)*. IEEE. 2015, pp. 3352–3357.
- [128] Silvia Guillén Ruiz et al. "Best Practices for Developing Socially-Aware Service Robots with Predictive Techniques to Enhance Social Comfort". In: *2023 3rd International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME)*. 2023 3rd International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME). Tener-

- ife, Canary Islands, Spain: IEEE, July 19, 2023, pp. 1–6. DOI: 10.1109/iceccme57830.2023.10252708. URL: <https://ieeexplore.ieee.org/document/10252708/> (visited on 07/14/2025).
- [129] Federico Sacco, Carmine Recchiuto, and Jonas Mårtensson. “A Novel Social Navigation Approach Based on Model Predictive Control and Social Force Model”. In: *2024 33rd IEEE International Conference on Robot and Human Interactive Communication (ROMAN)*. 2024 33rd IEEE International Conference on Robot and Human Interactive Communication (ROMAN). Pasadena, CA, USA: IEEE, Aug. 26, 2024, pp. 1705–1711. DOI: 10.1109/ro-man60168.2024.10731256. URL: <https://ieeexplore.ieee.org/document/10731256/> (visited on 07/14/2025).
- [130] Roya Salek Shahrezaie et al. “Advancing Socially-Aware Navigation for Public Spaces”. In: *2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Napoli, Italy: IEEE, Aug. 29, 2022, pp. 1015–1022. DOI: 10.1109/ro-man53752.2022.9900653. URL: <https://ieeexplore.ieee.org/document/9900653/> (visited on 07/14/2025).
- [131] Sepehr Samavi et al. “SICNav: Safe and Interactive Crowd Navigation Using Model Predictive Control and Bilevel Optimization”. In: *IEEE Transactions on Robotics* 41 (2025). Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 801–818. ISSN: 1552-3098, 1941-0468. DOI: 10.1109/tro.2024.3484634. URL: <https://ieeexplore.ieee.org/document/10726864/> (visited on 07/14/2025).
- [132] Adarsh Jagan Sathyamoorthy et al. “CoMet: Modeling Group Cohesion for Socially Compliant Robot Navigation in Crowded Scenes”. In: *IEEE Robotics and Automation Letters* 7.2 (Apr. 2022). Number: 2 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 1008–1015. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2021.3135560. URL: <https://ieeexplore.ieee.org/document/9652056/> (visited on 07/14/2025).
- [133] Adarsh Jagan Sathyamoorthy et al. “Denseavoid: Real-time navigation in dense crowds using anticipatory behaviors”. In: *2020 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE. 2020, pp. 11345–11352.
- [134] Adarsh Jagan Sathyamoorthy et al. “Frozone: Freezing-free, pedestrian-friendly navigation in human crowds”. In: *IEEE Robotics and Automation Letters* 5.3 (2020), pp. 4352–4359.
- [135] Philip Scales, Veronique Auberge, and Olivier Aycard. “Socio-expressive Robot Navigation: How Motion Profiles can convey Frailty and Confidence”. In: *2022 10th International Conference on Affective Computing and Intelligent Interaction Workshops and Demos (ACIIW)*. 2022 10th International Conference on Affective Computing and Intelligent Interaction Workshops and Demos (ACIIW). Nara, Japan: IEEE, Oct. 18, 2022, pp. 1–8. DOI: 10.1109/aciiw57231.2022.10086013. URL: <https://ieeexplore.ieee.org/document/10086013/> (visited on 07/14/2025).
- [136] Philip Scales, Veronique Auberge, and Olivier Aycard. “Inducing Social Perceptions of a Mobile Robot for Human-Aware Navigation”. In: *2024 18th International Conference on Control, Automation, Robotics and Vision (ICARCV)*. 2024 18th International Conference on Control, Automation, Robotics and Vision (ICARCV). Dubai, United Arab Emirates: IEEE, Dec. 12, 2024, pp. 530–536. DOI: 10.1109/icarcv63323.2024.10821677. URL: <https://ieeexplore.ieee.org/document/10821677/> (visited on 07/14/2025).
- [137] Philip Scales, Olivier Aycard, and Veronique Auberge. “Studying Navigation as a Form of Interaction: a Design Approach for Social Robot Navigation Methods”. In: *2020 IEEE International Conference on Robotics and Automation (ICRA)*. 2020 IEEE International Conference on Robotics and Automation (ICRA). Paris, France: IEEE, May 2020, pp. 6965–6972. DOI: 10.1109/icra40945.2020.9197037. URL: <https://ieeexplore.ieee.org/document/9197037/> (visited on 07/14/2025).
- [138] John Schulman et al. “Proximal policy optimization algorithms”. In: *arXiv preprint arXiv:1707.06347* (2017).
- [139] Emmanuel Senft, Satoru Satake, and Takayuki Kanda. “Would You Mind Me if I Pass by You?: Socially-Appropriate Behaviour for an Omni-based Social Robot in Narrow Environment”. In: *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. HRI ’20: ACM/IEEE International Conference on Human-Robot Interaction. Cambridge United Kingdom: ACM, Mar. 9, 2020, pp. 539–547. DOI: 10.1145/3319502.3374812. URL: <https://dl.acm.org/doi/10.1145/3319502.3374812> (visited on 07/14/2025).
- [140] Ishneet Sethi et al. “Group-Aware Human Trajectory Prediction”. In: *2022 IEEE 6th Conference on Information and Communication Technology (CICT)*. 2022 IEEE 6th Conference on Information and Communication Technology (CICT). Gwalior, India: IEEE, Nov. 18, 2022, pp. 1–5. DOI: 10.1109/cict56698.2022.9997980. URL: <https://ieeexplore.ieee.org/document/9997980/> (visited on 07/14/2025).

- [141] Abdulaziz Shamsah et al. "Real-time Model Predictive Control with Zonotope-Based Neural Networks for Bipedal Social Navigation". In: *2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Abu Dhabi, United Arab Emirates: IEEE, Oct. 14, 2024, pp. 13741–13748. DOI: 10.1109/iros58592.2024.10801435. URL: <https://ieeexplore.ieee.org/document/10801435/> (visited on 07/14/2025).
- [142] Abdulaziz Shamsah et al. "Socially Acceptable Bipedal Robot Navigation via Social Zonotope Network Model Predictive Control". In: *IEEE Transactions on Automation Science and Engineering* 22 (2025). Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 10130–10148. ISSN: 1545-5955, 1558-3783. DOI: 10.1109/tase.2024.3519012. URL: <https://ieeexplore.ieee.org/document/10810741/> (visited on 07/14/2025).
- [143] Akira Shiba et al. "Look Further: Socially-Compliant Navigation System in Residential Buildings". In: *2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI). Melbourne, Australia: IEEE, Mar. 4, 2025, pp. 272–282. DOI: 10.1109/hri61500.2025.10973828. URL: <https://ieeexplore.ieee.org/document/10973828/> (visited on 07/14/2025).
- [144] Heli Neres Silva et al. "Proposal of a Multimodal Interactive Architecture Based on a Social Indoor and Outdoor Navigation System". In: *2023 Latin American Robotics Symposium (LARS), 2023 Brazilian Symposium on Robotics (SBR), and 2023 Workshop on Robotics in Education (WRE)*. 2023 Latin American Robotics Symposium (LARS), 2023 Brazilian Symposium on Robotics (SBR), and 2023 Workshop on Robotics in Education (WRE). Salvador, Brazil: IEEE, Oct. 9, 2023, pp. 397–402. DOI: 10.1109/lars/sbr/wre59448.2023.10332955. URL: <https://ieeexplore.ieee.org/document/10332955/> (visited on 07/14/2025).
- [145] Steven Silva et al. "Online Social Robot Navigation in Indoor, Large and Crowded Environments". In: *2023 IEEE International Conference on Robotics and Automation (ICRA)*. 2023 IEEE International Conference on Robotics and Automation (ICRA). London, United Kingdom: IEEE, May 29, 2023, pp. 9749–9756. DOI: 10.1109/icra48891.2023.10160603. URL: <https://ieeexplore.ieee.org/document/10160603/> (visited on 07/14/2025).
- [146] Steven Silva et al. "Towards Online Socially Acceptable Robot Navigation". In: *2022 IEEE 18th International Conference on Automation Science and Engineering (CASE)*. 2022 IEEE 18th International Conference on Automation Science and Engineering (CASE). Mexico City, Mexico: IEEE, Aug. 20, 2022, pp. 707–714. DOI: 10.1109/case49997.2022.9926686. URL: <https://ieeexplore.ieee.org/document/9926686/> (visited on 07/14/2025).
- [147] Phani Teja Singamaneni, Anthony Favier, and Rachid Alami. "Human-aware navigation planner for diverse human-robot interaction contexts". In: *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2021, pp. 5817–5824.
- [148] Phani Teja Singamaneni, Anthony Favier, and Rachid Alami. "Towards Benchmarking Human-Aware Social Robot Navigation: A New Perspective and Metrics". In: *2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Busan, Korea, Republic of: IEEE, Aug. 28, 2023, pp. 914–921. DOI: 10.1109/ro-man57019.2023.10309398. URL: <https://ieeexplore.ieee.org/document/10309398/> (visited on 07/14/2025).
- [149] Phani Teja Singamaneni, Anthony Favier, and Rachid Alami. "Watch out! There may be a Human. Addressing Invisible Humans in Social Navigation". In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Kyoto, Japan: IEEE, Oct. 23, 2022, pp. 11344–11351. DOI: 10.1109/iros47612.2022.9982186. URL: <https://ieeexplore.ieee.org/document/9982186/> (visited on 07/14/2025).
- [150] Daeun Song et al. "VLM-Social-Nav: Socially Aware Robot Navigation Through Scoring Using Vision-Language Models". In: *IEEE Robotics and Automation Letters* 10.1 (Jan. 2025). Number: 1 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 508–515. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2024.3511409. URL: <https://ieeexplore.ieee.org/document/10777573/> (visited on 07/14/2025).
- [151] Andrew Stratton, Kris Hauser, and Christoforos Mavrogiannis. "Characterizing the Complexity of Social Robot Navigation Scenarios". In: *IEEE Robotics and Automation Letters* 10.1 (Jan. 2025). Number: 1 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 184–191. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2024.3502060. URL: <https://ieeexplore.ieee.org/document/10758252/> (visited on 07/14/2025).
- [152] Ada V. Taylor, Ellie Mamantov, and Henny Admoni. "Observer-Aware Legibility for Social Navigation".

- In: *2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. 2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). Napoli, Italy: IEEE, Aug. 29, 2022, pp. 1115–1122. DOI: 10.1109/ro-man53752.2022.9900676. URL: <https://ieeexplore.ieee.org/document/9900676/> (visited on 07/14/2025).
- [153] Angelique Taylor and Laurel D. Riek. “REGROUP: A Robot-Centric Group Detection and Tracking System”. In: *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI). Sapporo, Japan: IEEE, Mar. 7, 2022, pp. 412–421. DOI: 10.1109/hri53351.2022.9889634. URL: <https://ieeexplore.ieee.org/document/9889634/> (visited on 07/14/2025).
- [154] Angelique M. Taylor et al. “Social Navigation for Mobile Robots in the Emergency Department”. In: *2021 IEEE International Conference on Robotics and Automation (ICRA)*. 2021 IEEE International Conference on Robotics and Automation (ICRA). Xi’an, China: IEEE, May 30, 2021, pp. 3510–3516. DOI: 10.1109/icra48506.2021.9561897. URL: <https://ieeexplore.ieee.org/document/9561897/> (visited on 07/14/2025).
- [155] Behrad Toghi et al. “Social Coordination and Altruism in Autonomous Driving”. In: *IEEE Transactions on Intelligent Transportation Systems* 23.12 (Dec. 2022). Number: 12 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 24791–24804. ISSN: 1524-9050, 1558-0016. DOI: 10.1109/tits.2022.3207872. URL: <https://ieeexplore.ieee.org/document/9905741/> (visited on 07/14/2025).
- [156] Faraz Torabi, Garrett Warnell, and Peter Stone. “Generative adversarial imitation from observation”. In: *arXiv preprint arXiv:1807.06158* (2018).
- [157] Xuan-Tung Truong and Trung Dung Ngo. “Toward socially aware robot navigation in dynamic and crowded environments: A proactive social motion model”. In: *IEEE Transactions on Automation Science and Engineering* 14.4 (2017), pp. 1743–1760.
- [158] Chieh-En Tsai and Jean Oh. “A Generative Approach for Socially Compliant Navigation”. In: *2020 IEEE International Conference on Robotics and Automation (ICRA)*. 2020 IEEE International Conference on Robotics and Automation (ICRA). Paris, France: IEEE, May 2020, pp. 2160–2166. DOI: 10.1109/icra40945.2020.9197497. URL: <https://ieeexplore.ieee.org/document/9197497/> (visited on 07/14/2025).
- [159] Nathan Tsoi et al. “An Approach to Deploy Interactive Robotic Simulators on the Web for HRI Experiments: Results in Social Robot Navigation”. In: *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Prague, Czech Republic: IEEE, Sept. 27, 2021, pp. 7528–7535. DOI: 10.1109/iros51168.2021.9636319. URL: <https://ieeexplore.ieee.org/document/9636319/> (visited on 07/14/2025).
- [160] Nathan Tsoi et al. “SEAN 2.0: Formalizing and Generating Social Situations for Robot Navigation”. In: *IEEE Robotics and Automation Letters* 7.4 (Oct. 2022). Number: 4 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 11047–11054. ISSN: 2377-3766, 2377-3774. DOI: 10.1109/lra.2022.3196783. URL: <https://ieeexplore.ieee.org/document/9851501/> (visited on 07/14/2025).
- [161] Rodolfo Valiente et al. “Prediction-Aware and Reinforcement Learning-Based Altruistic Cooperative Driving”. In: *IEEE Transactions on Intelligent Transportation Systems* 25.3 (Mar. 2024). Number: 3 Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 2450–2465. ISSN: 1524-9050, 1558-0016. DOI: 10.1109/tits.2023.3323440. URL: <https://ieeexplore.ieee.org/document/10292587/> (visited on 07/14/2025).
- [162] Rodolfo Valiente et al. “Prediction-aware and reinforcement learning-based altruistic cooperative driving”. In: *IEEE Transactions on Intelligent Transportation Systems* 25.3 (2023), pp. 2450–2465.
- [163] Jur Van Den Berg et al. “Reciprocal n-body collision avoidance”. In: *Robotics Research: The 14th International Symposium ISRR*. Springer. 2011, pp. 3–19.
- [164] S. Batuhan Vatan, Kemal Bektaş, and H. Işıl Bozma. “Social APF-RL: Safe Mapless Navigation in Unknown & Human-Populated Environments”. In: *2023 European Conference on Mobile Robots (ECMR)*. 2023 European Conference on Mobile Robots (ECMR). Coimbra, Portugal: IEEE, Sept. 4, 2023, pp. 1–6. DOI: 10.1109/ecmr59166.2023.10256274. URL: <https://ieeexplore.ieee.org/document/10256274/> (visited on 07/14/2025).
- [165] Araceli Vega et al. “Socially aware robot navigation system in human-populated and interactive environments based on an adaptive spatial density function and space affordances”. In: *Pattern Recognition Letters* 118 (2019), pp. 72–84.
- [166] A. Vega-Magro et al. “Human-aware Robot Navigation based on Time-dependent Social Interaction Spaces: a use case for assistive robotics”. In: *2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC)*. 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC). Ponta Delgada, Portugal: IEEE, Apr. 2020, pp. 140–

145. DOI: 10.1109/icarsc49921.2020.9096113. URL: <https://ieeexplore.ieee.org/document/9096113/> (visited on 07/14/2025).
- [167] A. Vega-Magro et al. "Towards efficient human-robot cooperation for socially-aware robot navigation in human-populated environments: the SNAPE framework". In: *2021 IEEE International Conference on Robotics and Automation (ICRA)*. 2021 IEEE International Conference on Robotics and Automation (ICRA). Xi'an, China: IEEE, May 30, 2021, pp. 3169–3174. DOI: 10.1109/icra48506.2021.9561448. URL: <https://ieeexplore.ieee.org/document/9561448/> (visited on 07/14/2025).
- [168] Joao Pedro Vilasboas et al. "Application of social constraints for dynamic navigation considering semantic annotations on geo-referenced maps". In: *IECON 2021 – 47th Annual Conference of the IEEE Industrial Electronics Society*. IECON 2021 - 47th Annual Conference of the IEEE Industrial Electronics Society. Toronto, ON, Canada: IEEE, Oct. 13, 2021, pp. 1–7. DOI: 10.1109/iecon48115.2021.9589235. URL: <https://ieeexplore.ieee.org/document/9589235/> (visited on 07/14/2025).
- [169] Allan Wang et al. "TBD Pedestrian Data Collection: Towards Rich, Portable, and Large-Scale Natural Pedestrian Data". In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 637–644. DOI: 10.1109/icra57147.2024.10610335. URL: <https://ieeexplore.ieee.org/document/10610335/> (visited on 07/14/2025).
- [170] Shuaijun Wang et al. "Adaptive environment modeling based reinforcement learning for collision avoidance in complex scenes". In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2022, pp. 9011–9018.
- [171] Weizheng Wang et al. "Multi-Robot Cooperative Socially-Aware Navigation Using Multi-Agent Reinforcement Learning". In: *2024 IEEE International Conference on Robotics and Automation (ICRA)*. 2024 IEEE International Conference on Robotics and Automation (ICRA). Yokohama, Japan: IEEE, May 13, 2024, pp. 12353–12360. DOI: 10.1109/icra57147.2024.10611322. URL: <https://ieeexplore.ieee.org/document/10611322/> (visited on 07/14/2025).
- [172] Weizheng Wang et al. "NaviSTAR: Socially Aware Robot Navigation with Hybrid Spatio-Temporal Graph Transformer and Preference Learning". In: *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). Detroit, MI, USA: IEEE, Oct. 1, 2023, pp. 11348–11355. DOI: 10.1109/iros55552.2023.10341395. URL: <https://ieeexplore.ieee.org/document/10341395/> (visited on 07/14/2025).
- [173] Tim Weissker, Pauline Bimberg, and Bernd Froehlich. "An Overview of Group Navigation in Multi-User Virtual Reality". In: *2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. 2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW). Lisbon, Portugal: IEEE, Mar. 2021, pp. 363–369. DOI: 10.1109/vrw52623.2021.00073. URL: <https://ieeexplore.ieee.org/document/9419104/> (visited on 07/14/2025).
- [174] Markus Wulfmeier, Peter Ondruska, and Ingmar Posner. "Maximum entropy deep inverse reinforcement learning". In: *arXiv preprint arXiv:1507.04888* (2015).
- [175] Xuesu Xiao et al. "Appld: Adaptive planner parameter learning from demonstration". In: *IEEE Robotics and Automation Letters* 5.3 (2020), pp. 4541–4547.
- [176] Zhanteng Xie and Philip Dames. "DRL-VO: Learning to navigate through crowded dynamic scenes using velocity obstacles". In: *IEEE Transactions on Robotics* 39.4 (2023), pp. 2700–2719.
- [177] Xujun Xu et al. "Social Robot Navigation and Comfortable Following: A Novel Knowledge-Based Robot-Pedestrian Interaction Model with Self Learning Strategy". In: *2023 IEEE International Conference on Robotics and Biomimetics (ROBIO)*. 2023 IEEE International Conference on Robotics and Biomimetics (ROBIO). Koh Samui, Thailand: IEEE, Dec. 4, 2023, pp. 1–7. DOI: 10.1109/robio58561.2023.10355040. URL: <https://ieeexplore.ieee.org/document/10355040/> (visited on 07/14/2025).
- [178] Yifan Xu et al. "SoLo T-DIRL: Socially-Aware Dynamic Local Planner based on Trajectory-Ranked Deep Inverse Reinforcement Learning". In: *2023 IEEE International Conference on Robotics and Automation (ICRA)*. 2023 IEEE International Conference on Robotics and Automation (ICRA). London, United Kingdom: IEEE, May 29, 2023, pp. 12045–12051. DOI: 10.1109/icra48891.2023.10160536. URL: <https://ieeexplore.ieee.org/document/10160536/> (visited on 07/14/2025).
- [179] Yuxiang Yang et al. "ST2: Spatial-temporal state transformer for crowd-aware autonomous navigation". In: *IEEE Robotics and Automation Letters* 8.2 (2023), pp. 912–919.
- [180] Hanjing Ye et al. "Rpf-search: Field-based search for robot person following in unknown dynamic environments". In: *arXiv preprint arXiv:2503.02188* (2025).

- [181] Joel Ye et al. “Auxiliary tasks speed up learning point goal navigation”. In: *Conference on Robot Learning*. PMLR. 2021, pp. 498–516.
- [182] Naoki Yokoyama et al. In: *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE. 2022, pp. 1748–1755.
- [183] Kai Zhu, Tao Xue, and Tao Zhang. “Confidence-Aware Robust Dynamical Distance Constrained Reinforcement Learning for Social Robot Navigation”. In: *IEEE Transactions on Automation Science and Engineering* 22 (2025). Publisher: Institute of Electrical and Electronics Engineers (IEEE), pp. 16572–16590. ISSN: 1545-5955, 1558-3783. DOI: 10 . 1109 / tase . 2025 . 3578326. URL: <https://ieeexplore.ieee.org/document/11029302/> (visited on 07/14/2025).
- [184] Kai Zhu and Tao Zhang. “Deep reinforcement learning based mobile robot navigation: A review”. In: *Tsinghua Science and Technology* 26.5 (Oct. 2021). Number: 5 Publisher: Tsinghua University Press, pp. 674–691. ISSN: 1007-0214. DOI: 10 . 26599 / tst . 2021 . 9010012. URL: <https://ieeexplore.ieee.org/document/9409758/> (visited on 07/14/2025).