

A compass towards equity: a data analysis framework to capture children's behaviour in the playground context Nasri, M.

Citation

Nasri, M. (2024, December 3). A compass towards equity: a data analysis framework to capture children's behaviour in the playground context. Retrieved from https://hdl.handle.net/1887/4170540

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Note: To cite this publication please use the final published version (if applicable).

- M. Nasri, Y.-T. Tsou, A. Koutamanis, M. Baratchi, S. Giest, D. Reidsma, and C. Rieffe, "A novel data-driven approach to examine children's movements and social behaviour in schoolyard environments," *Children*, vol. 9, no. 8, p. 1177, 2022.
- [2] M. Nasri, M. Baratchi, Y.-T. Tsou, S. Giest, A. Koutamanis, and C. Rieffe, "A novel metric to measure spatio-temporal proximity: a case study analyzing children's social network in schoolyards," *Applied Network Science*, vol. 8, no. 1, p. 50, 2023.
- [3] M. Nasri, Z. Fang, M. Baratchi, G. Englebienne, S. Wang, A. Koutamanis, and C. Rieffe, "A gnn-based architecture for group detection from spatio-temporal trajectory data," in *International Symposium on Intelligent Data Analysis*, pp. 327–339, Springer, 2023.
- [4] M. Nasri, T. Maliappis, C. Rieffe, and M. Baratchi, "T-dante: Detecting group behaviour in spatio-temporal trajectories using context information," in *International Symposium on Intelligent Data Analysis*, pp. 28–39, Springer, 2024.
- [5] Y.-T. Tsou, M. Nasri, B. Li, E. M. Blijd-Hoogewys, M. Baratchi, A. Koutamanis, and C. Rieffe, "Social connectedness and loneliness in school for autistic and allistic children," *Autism*, p. 13623613241259932, 2024.
- [6] M. Nasri, S. Giest, Y.-T. Tsou, M. Baratchi, A. Koutamanis, and C. Rieffe, "Role of movement data in creating inclusive school settings for students," in *Data for Policy*, 2022.
- [7] A. Eichengreen, M. van Rooijen, L.-M. van Klaveren, M. Nasri, Y.-T. Tsou, A. Koutamanis, M. Baratchi, and C. Rieffe, "The impact of loose-parts-play on schoolyard social participation of children with and without disabilities: A case study," *Child: care, health and development*, vol. 50, no. 1, p. e13144, 2024.
- [8] A. Eichengreen, Y.-T. Tsou, M. Nasri, L.-M. van Klaveren, B. Li, A. Koutamanis, M. Baratchi, E. Blijd-Hoogewys, J. Kok, and C. Rieffe, "Social connectedness at the playground before and after covid-19 school closure," *Journal of applied developmental psychol*ogy, vol. 87, p. 101562, 2023.
- [9] R. Laanen, M. Nasri, R. van Dijk, M. Baratchi, A. Koutamanis, and C. Rieffe, "Automated classification of pre-defined movement patterns: A comparison between gnss and uwb technology," arXiv preprint arXiv:2303.07107, 2023.

- [10] P. Diotaiuti, S. Mancone, and S. Corrado, "Using sports tracker: evidences on dependence, self-regulatory modes and resilience in a sample of competitive runners," *Psychology*, vol. 11, no. 1, pp. 54–70, 2020.
- [11] N. De Raeve, A. Shahid, M. De Schepper, E. De Poorter, I. Moerman, J. Verhaevert, P. Van Torre, and H. Rogier, "Bluetooth-low-energy-based fall detection and warning system for elderly people in nursing homes," *Journal of Sensors*, vol. 2022, pp. 1–14, 2022.
- [12] A. V. Creaser, S. A. Clemes, S. Costa, J. Hall, N. D. Ridgers, S. E. Barber, and D. D. Bingham, "The acceptability, feasibility, and effectiveness of wearable activity trackers for increasing physical activity in children and adolescents: a systematic review," *International journal of environmental research and public health*, vol. 18, no. 12, p. 6211, 2021.
- [13] J. E. Druery, "Fostering sense of belonging: a multi-case study of black male retention initiatives.," *Electronic Theses and Dissertations.*, 2018.
- [14] P. I. Karlsudd, "Inclusion through participation: Fostering pupils' feelings of belonging in swedish after-school care," *Education Sciences*, vol. 13, no. 4, p. 376, 2023.
- [15] S. B. Sarason, "The psychological sense of community," San Francisco, 1974.
- [16] J. E. van Dijk-Wesselius, A. E. Van den Berg, J. Maas, and D. Hovinga, "Green schoolyards as outdoor learning environments: Barriers and solutions as experienced by primary school teachers," *Frontiers in Psychology*, vol. 10, p. 484511, 2020.
- [17] M. E. van den Berg, M. Winsall, S. M. Dyer, F. Breen, M. Gresham, and M. Crotty, "Understanding the barriers and enablers to using outdoor spaces in nursing homes: A systematic review," *The gerontologist*, vol. 60, no. 4, pp. e254–e269, 2020.
- [18] L. Basterfield, L. Gardner, J. K. Reilly, M. S. Pearce, K. N. Parkinson, A. J. Adamson, J. J. Reilly, and S. A. Vella, "Can't play, won't play: longitudinal changes in perceived barriers to participation in sports clubs across the child–adolescent transition," *BMJ open sport & exercise medicine*, vol. 2, no. 1, p. e000079, 2016.
- [19] R. J. Coplan, L. L. Ooi, A. Kirkpatrick, and K. H. Rubin, "Social and nonsocial play," in Play from birth to twelve, pp. 97–106, Routledge, 2015.
- [20] F. Madondo and J. Tsikira, "Traditional children's games: their relevance on skills development among rural zimbabwean children age 3–8 years," *Journal of Research in Childhood Education*, vol. 36, no. 3, pp. 406–420, 2022.
- [21] C. S. González, N. Gómez, V. Navarro, M. Cairós, C. Quirce, P. Toledo, and N. Marrero-Gordillo, "Learning healthy lifestyles through active videogames, motor games and the gamification of educational activities," *Computers in human behavior*, vol. 55, pp. 529–551, 2016.
- [22] B. A. Cheatum and A. A. Hammond, Physical activities for improving children's learning and behavior: A guide to sensory motor development. Human Kinetics, 2000.
- [23] A. J. Hanscom, Balanced and barefoot: How unrestricted outdoor play makes for strong, confident, and capable children. New Harbinger Publications, 2016.
- [24] B. A. Corbett, C. W. Schupp, S. Levine, and S. Mendoza, "Comparing cortisol, stress, and sensory sensitivity in children with autism," *Autism research*, vol. 2, no. 1, pp. 39–49, 2009.
- [25] A. E. Robertson and D. R. Simmons, "The relationship between sensory sensitivity and autistic traits in the general population," *Journal of Autism and Developmental disorders*, vol. 43, pp. 775–784, 2013.

- [26] N. J. Minshew and J. A. Hobson, "Sensory sensitivities and performance on sensory perceptual tasks in high-functioning individuals with autism," *Journal of autism and developmental disorders*, vol. 38, pp. 1485–1498, 2008.
- [27] J. G. Parker and S. R. Asher, "Friendship and friendship quality in middle childhood: Links with peer group acceptance and feelings of loneliness and social dissatisfaction.," *Developmental psychology*, vol. 29, no. 4, p. 611, 1993.
- [28] J. Sparkes, "Schools, education and social exclusion," LSE STICERD Research Paper No. CASE029, 1999.
- [29] N. Bauminger and C. Kasari, "Loneliness and friendship in high-functioning children with autism," *Child development*, vol. 71, no. 2, pp. 447–456, 2000.
- [30] R. J. Coplan, L. L. Ooi, and L. Rose-Krasnor, "Naturalistic observations of schoolyard social participation: Marker variables for socio-emotional functioning in early adolescence," *The Journal of Early Adolescence*, vol. 35, no. 5-6, pp. 628–650, 2015.
- [31] S. P. Hinshaw, C. Simmel, and T. L. Heller, "Multimethod assessment of covert antisocial behavior in children: Laboratory observations, adult ratings, and child self-report.," *Psychological Assessment*, vol. 7, no. 2, p. 209, 1995.
- [32] T. Bouman, M. van der Meulen, F. A. Goossens, T. Olthof, M. M. Vermande, and E. A. Aleva, "Peer and self-reports of victimization and bullying: Their differential association with internalizing problems and social adjustment," *Journal of school psychology*, vol. 50, no. 6, pp. 759–774, 2012.
- [33] D. Dessing, F. H. Pierik, R. P. Sterkenburg, P. van Dommelen, J. Maas, and S. I. de Vries, "Schoolyard physical activity of 6–11 year old children assessed by gps and accelerometry," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 10, pp. 1–9, 2013.
- [34] C. S. Pawlowski, H. B. Andersen, J. Troelsen, and J. Schipperijn, "Children's physical activity behavior during school recess: A pilot study using gps, accelerometer, participant observation, and go-along interview," *PloS one*, vol. 11, no. 2, p. e0148786, 2016.
- [35] G. Veiga, W. De Leng, R. Cachucho, L. Ketelaar, J. N. Kok, A. Knobbe, C. Neto, and C. Rieffe, "Social competence at the playground: Preschoolers during recess," *Infant and Child Development*, vol. 26, no. 1, p. e1957, 2017.
- [36] G. Veiga, L. Ketelaar, W. De Leng, R. Cachucho, J. N. Kok, A. Knobbe, C. Neto, and C. Rieffe, "Alone at the playground," *European Journal of Developmental Psychology*, vol. 14, no. 1, pp. 44–61, 2017.
- [37] J. Amirian, B. Zhang, F. V. Castro, J. J. Baldelomar, J.-B. Hayet, and J. Pettré, "Opentraj: Assessing prediction complexity in human trajectories datasets," in *Proceedings of the asian* conference on computer vision, 2020.
- [38] F. Aminpour, K. Bishop, and L. Corkery, "The hidden value of in-between spaces for children's self-directed play within outdoor school environments," *Landscape and urban planning*, vol. 194, p. 103683, 2020.
- [39] J. L. Huberty, M. W. Beets, A. Beighle, and G. Welk, "Environmental modifications to increase physical activity during recess: preliminary findings from ready for recess," *Journal* of Physical Activity and Health, vol. 8, no. s2, pp. S249–S256, 2011.
- [40] E. Baines and P. Blatchford, "Full report-school break and lunch times and young people's social lives: a follow-up national study," tech. rep., UCL Institute of Education, 2019.

- [41] J. S. Owen-DeSchryver, E. G. Carr, S. I. Cale, and A. Blakeley-Smith, "Promoting social interactions between students with autism spectrum disorders and their peers in inclusive school settings," *Focus on Autism and other developmental disabilities*, vol. 23, no. 1, pp. 15–28, 2008.
- [42] S. J. Slater, L. Nicholson, J. Chriqui, L. Turner, and F. Chaloupka, "The impact of state laws and district policies on physical education and recess practices in a nationally representative sample of us public elementary schools," *Archives of pediatrics & adolescent medicine*, vol. 166, no. 4, pp. 311–316, 2012.
- [43] R. M. Stanley, K. Boshoff, and J. Dollman, "Voices in the playground: A qualitative exploration of the barriers and facilitators of lunchtime play," *Journal of science and medicine in sport*, vol. 15, no. 1, pp. 44–51, 2012.
- [44] A. Jerebine, K. Fitton-Davies, N. Lander, E. L. Eyre, M. J. Duncan, and L. M. Barnett, ""all the fun stuff, the teachers say, 'that's dangerous!'" hearing from children on safety and risk in active play in schools: a systematic," *Int J Behav Nutr Phys Act 19*, 2022.
- [45] H. Heft, "Affordances of children's environments: A functional approach to environmental description," *Children's environments quarterly*, pp. 29–37, 1988.
- [46] M. Kyttä, "Affordances of children's environments in the context of cities, small towns, suburbs and rural villages in finland and belarus," *Journal of environmental psychology*, vol. 22, no. 1-2, pp. 109–123, 2002.
- [47] V. Sharma-Brymer, K. Davids, E. Brymer, and D. Bland, "Affordances in nature: Australian primary school children identify learning opportunities," *Curriculum Perspectives*, vol. 38, pp. 175–180, 2018.
- [48] N. G. Cosco, R. C. Moore, and M. Z. Islam, "Behavior mapping: A method for linking preschool physical activity and outdoor design," *Medicine & Science in Sports & Exercise*, vol. 42, no. 3, pp. 513–519, 2010.
- [49] W. R. Smith, R. Moore, N. Cosco, J. Wesoloski, T. Danninger, D. S. Ward, S. G. Trost, and N. Ries, "Increasing physical activity in childcare outdoor learning environments: The effect of setting adjacency relative to other built environment and social factors," *Environment and behavior*, vol. 48, no. 4, pp. 550–578, 2016.
- [50] F. S. Flores, L. P. Rodrigues, F. Copetti, F. Lopes, and R. Cordovil, "Affordances for motor skill development in home, school, and sport environments: A narrative review," *Perceptual* and motor skills, vol. 126, no. 3, pp. 366–388, 2019.
- [51] K. Bjørgen, "Physical activity in light of affordances in outdoor environments: qualitative observation studies of 3–5 years olds in kindergarten," *Springerplus*, vol. 5, no. 1, pp. 1–11, 2016.
- [52] S. Everley and K. Everley, "Primary school children's experiences of physical activity: The place of social and cultural capital in participation and implications for schools," *Early Child Development and Care*, vol. 189, no. 12, pp. 2032–2042, 2019.
- [53] A. Zaidman-Zait, P. Mirenda, E. Duku, T. Vaillancourt, I. M. Smith, P. Szatmari, S. Bryson, E. Fombonne, J. Volden, C. Waddell, *et al.*, "Impact of personal and social resources on parenting stress in mothers of children with autism spectrum disorder," *Autism*, vol. 21, no. 2, pp. 155–166, 2017.
- [54] A. M. Bednarczyk, H. Alexander-Whiting, and G. A. Solit, "Guidelines for the adaptation of preschool environments to integrate deaf, hard of hearing, and hearing children," *Children's Environments*, pp. 6–15, 1994.

- [55] S. D. Mayes, S. L. Calhoun, R. Aggarwal, C. Baker, S. Mathapati, S. Molitoris, and R. D. Mayes, "Unusual fears in children with autism," *Research in Autism Spectrum Disorders*, vol. 7, no. 1, pp. 151–158, 2013.
- [56] A. Franklin, P. Sowden, R. Burley, L. Notman, and E. Alder, "Color perception in children with autism," *Journal of autism and developmental disorders*, vol. 38, pp. 1837–1847, 2008.
- [57] Q. Wu, C. Yu, Y. Chen, J. Yao, X. Wu, X. Peng, and T. Han, "Squeeze the ball: Designing an interactive playground towards aiding social activities of children with low-function autism," in *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1–14, 2020.
- [58] M. Hudson, H. G. Burnett, and T. Jellema, "Anticipation of action intentions in autism spectrum disorder," *Journal of autism and developmental disorders*, vol. 42, pp. 1684–1693, 2012.
- [59] D. W. Maynard, T. McDonald, and T. Stickle, "Parents as a team: Mother, father, a child with autism spectrum disorder, and a spinning toy," *Journal of autism and developmental disorders*, vol. 46, pp. 406–423, 2016.
- [60] S. C. Wymer, J. Tarbox, G. A. Beavers, and C. A. Tullis, "Teaching children with autism to follow rules specifying a behavior and consequence," *The Analysis of Verbal Behavior*, vol. 32, pp. 265–274, 2016.
- [61] P. Brambilla, A. Hardan, S. U. Di Nemi, J. Perez, J. C. Soares, and F. Barale, "Brain anatomy and development in autism: review of structural mri studies," *Brain research bulletin*, vol. 61, no. 6, pp. 557–569, 2003.
- [62] S. M. Alessandri, "Attention, play, and social behavior in adhd preschoolers," Journal of abnormal child psychology, vol. 20, pp. 289–302, 1992.
- [63] R. Cordier, A. Bundy, C. Hocking, and S. Einfeld, "A model for play-based intervention for children with adhd," *Australian Occupational Therapy Journal*, vol. 56, no. 5, pp. 332–340, 2009.
- [64] E. E. Leipold and A. C. Bundy, "Playfulness in children with attention deficit hyperactivity disorder," *The Occupational Therapy Journal of Research*, vol. 20, no. 1, pp. 61–79, 2000.
- [65] B. Da Silva, G. Veiga, and C. Rieffe, "A review on playground behaviors-the case of children with hearing loss," in ESTUDOS EM DESENYOLYIMENTO MOTOR DA CRIANCA, Edições Piaget, 2018.
- [66] C. Rieffe, P. Oosterveld, M. M. Terwogt, S. Mootz, E. Van Leeuwen, and L. Stockmann, "Emotion regulation and internalizing symptoms in children with autism spectrum disorders," *Autism*, vol. 15, no. 6, pp. 655–670, 2011.
- [67] B. F. Van Heijst and H. M. Geurts, "Quality of life in autism across the lifespan: A metaanalysis," Autism, vol. 19, no. 2, pp. 158–167, 2015.
- [68] I. Fjørtoft, B. Kristoffersen, and J. Sageie, "Children in schoolyards: Tracking movement patterns and physical activity in schoolyards using global positioning system and heart rate monitoring," *Landscape and urban planning*, vol. 93, no. 3-4, pp. 210–217, 2009.
- [69] A. P. Jones, E. G. Coombes, S. J. Griffin, and E. M. van Sluijs, "Environmental supportiveness for physical activity in english schoolchildren: a study using global positioning systems," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 6, no. 1, pp. 1–8, 2009.

- [70] R. Maddison and C. Ni Mhurchu, "Global positioning system: a new opportunity in physical activity measurement," *International journal of behavioral nutrition and physical activity*, vol. 6, no. 1, pp. 1–8, 2009.
- [71] J. S. Duncan, H. M. Badland, and G. Schofield, "Combining gps with heart rate monitoring to measure physical activity in children: A feasibility study," *Journal of Science and Medicine in Sport*, vol. 12, no. 5, pp. 583–585, 2009.
- [72] H. B. Andersen, L. B. Christiansen, C. S. Pawlowski, and J. Schipperijn, "What we build makes a difference-mapping activating schoolyard features after renewal using gis, gps and accelerometers," *Landscape and Urban Planning*, vol. 191, p. 103617, 2019.
- [73] M. Kusenbach, "Street phenomenology: The go-along as ethnographic research tool," *Ethnography*, vol. 4, no. 3, pp. 455–485, 2003.
- [74] M. G. Wing, A. Eklund, and L. D. Kellogg, "Consumer-grade global positioning system (gps) accuracy and reliability," *Journal of forestry*, vol. 103, no. 4, pp. 169–173, 2005.
- [75] P. A. Zandbergen and S. J. Barbeau, "Positional accuracy of assisted gps data from highsensitivity gps-enabled mobile phones," *The Journal of Navigation*, vol. 64, no. 3, pp. 381– 399, 2011.
- [76] G. Veiga and C. Rieffe, "Monitoring children's behaviors in their natural settings: Applying rfid sensors to study child development," *Sage Research Methods Cases*, vol. 10, p. 9781526446435, 2018.
- [77] T. Elmer, K. Chaitanya, P. Purwar, and C. Stadtfeld, "The validity of rfid badges measuring face-to-face interactions," *Behavior research methods*, vol. 51, pp. 2120–2138, 2019.
- [78] M. R. Puyau, A. L. Adolph, F. A. Vohra, and N. F. Butte, "Validation and calibration of physical activity monitors in children," *Obesity research*, vol. 10, no. 3, pp. 150–157, 2002.
- [79] E. Delidou, O. Matsouka, and C. Nikolaidis, "Influence of school playground size and equipment on the physical activity of students during recess," *European Physical Education Review*, vol. 22, no. 2, pp. 215–224, 2016.
- [80] M. Jansson, M. Abdulah, and A. Eriksson, "Secondary school students' perspectives and use of three school grounds of varying size, content and design," Urban Forestry & Urban Greening, vol. 30, pp. 115–123, 2018.
- [81] L. Chawla, K. Keena, I. Pevec, and E. Stanley, "Green schoolyards as havens from stress and resources for resilience in childhood and adolescence," *Health & place*, vol. 28, pp. 1–13, 2014.
- [82] E. Haug, T. Torsheim, J. F. Sallis, and O. Samdal, "The characteristics of the outdoor school environment associated with physical activity," *Health education research*, vol. 25, no. 2, pp. 248–256, 2010.
- [83] M. Czalczynska-Podolska, "The impact of playground spatial features on children's play and activity forms: An evaluation of contemporary playgrounds' play and social value," *Journal* of environmental psychology, vol. 38, pp. 132–142, 2014.
- [84] D. P. Loy, J. Dattilo, et al., "Effects of different play structures on social interactions between a boy with asperger's syndrome and his peers," *Therapeutic Recreation Journal*, vol. 34, no. 3, pp. 190–210, 2000.
- [85] L. E. Cohen, "Layers of discourse in preschool block play: An examination of children's social interactions," *International Journal of Early Childhood*, vol. 47, pp. 267–281, 2015.

- [86] J. Van Dijk-Wesselius, J. Maas, D. Hovinga, M. Van Vugt, and A. Van den Berg, "The impact of greening schoolyards on the appreciation, and physical, cognitive and socialemotional well-being of schoolchildren: A prospective intervention study," *Landscape and urban planning*, vol. 180, pp. 15–26, 2018.
- [87] C. Wang, B. Berry, and S. M. Swearer, "The critical role of school climate in effective bullying prevention," *Theory into practice*, vol. 52, no. 4, pp. 296–302, 2013.
- [88] V. Djaja-Josko and J. Kolakowski, "Uwb positioning system for elderly persons monitoring," in 2015 23rd Telecommunications Forum Telfor (TELFOR), pp. 169–172, IEEE, 2015.
- [89] A. Van den Bossche, R. Dalce, N. Gonzalez, and T. Val, "Locura: A new localisation and uwb-based ranging testbed for the internet of things," in 2018 International Conference on Indoor Positioning and Indoor Navigation (IPIN), pp. 1–6, IEEE, 2018.
- [90] Y. Xu, Y. S. Shmaliy, C. K. Ahn, G. Tian, and X. Chen, "Robust and accurate uwb-based indoor robot localisation using integrated ekf/efir filtering," *IET radar, sonar & navigation*, vol. 12, no. 7, pp. 750–756, 2018.
- [91] B. M. Heravi, J. L. Gibson, S. Hailes, and D. Skuse, "Playground social interaction analysis using bespoke wearable sensors for tracking and motion capture," in *Proceedings of the 5th International Conference on Movement and Computing*, pp. 1–8, 2018.
- [92] D. Lusher, G. Robins, and P. Kremer, "The application of social network analysis to team sports," *Measurement in Physical Education and Exercise Science*, vol. 14, no. 4, pp. 211– 224, 2010.
- [93] X. Li, S. Geng, and S. Liu, "Social network analysis on tourists' perceived image of tropical forest park: Implications for niche tourism," SAGE Open, vol. 12, no. 1, p. 21582440211067243, 2022.
- [94] M. Valeri and R. Baggio, "Social network analysis: Organizational implications in tourism management," *International Journal of Organizational Analysis*, vol. 29, no. 2, pp. 342–353, 2020.
- [95] R. P. D. Redondo, C. Garcia-Rubio, A. F. Vilas, C. Campo, and A. Rodriguez-Carrion, "A hybrid analysis of lbsn data to early detect anomalies in crowd dynamics," *Future Generation Computer Systems*, vol. 109, pp. 83–94, 2020.
- [96] J. A. Barnes and F. Harary, "Graph theory in network analysis," Social Networks, vol. 5, no. 2, pp. 235–244, 1983.
- [97] A. Bavelas, "Communication patterns in task-oriented groups," The Journal of The Acoustical Society of America, vol. 22, no. 6, pp. 725–730, 1950.
- [98] V. Kostakos, "Temporal graphs," Physica A: Statistical Mechanics and its Applications, vol. 388, no. 6, pp. 1007–1023, 2009.
- [99] L. Franzini, M. N. Elliott, P. Cuccaro, M. Schuster, M. J. Gilliland, J. A. Grunbaum, F. Franklin, and S. R. Tortolero, "Influences of physical and social neighborhood environments on children's physical activity and obesity," *American Journal of Public Health*, vol. 99, no. 2, pp. 271–278, 2009.
- [100] A. Montanari, C. Mascolo, K. Sailer, and S. Nawaz, "Detecting emerging activity-based working traits through wearable technology," *Proceedings of the International Conference* (ACM) on Interactive, Mobile, Wearable and Ubiquitous Technologies, vol. 1, no. 3, pp. 1– 24, 2017.

- [101] B. Chaix, "How daily environments and situations shape behaviors and health: momentary studies of mobile sensing and smartphone survey data," *Health & Place*, vol. 61, p. 102241, 2020.
- [102] Z. Liu, X. Zhou, W. Shi, and A. Zhang, "Recommending attractive thematic regions by semantic community detection with multi-sourced vgi data," *International Journal of Geographical Information Science*, vol. 33, no. 8, pp. 1520–1544, 2019.
- [103] E. Steiger, J. P. De Albuquerque, and A. Zipf, "An advanced systematic literature review on spatiotemporal analyses of twitter data," *Transactions in GIS*, vol. 19, no. 6, pp. 809–834, 2015.
- [104] H. Advaith, S. Adarsh, G. Akshay, P. Sreeram, and G. Sajeev, "A proximity based community detection in temporal graphs," in *Proceedings of the International Conference on Electronics, Computing and Communication Technologies (CONECCT)*, pp. 1–6, IEEE, 2020.
- [105] H. A. Rahmani, M. Aliannejadi, M. Baratchi, and F. Crestani, "A systematic analysis on the impact of contextual information on point-of-interest recommendation," ACM Transactions on Information Systems (TOIS), vol. 40, no. 4, pp. 1–35, 2022.
- [106] Y. Zheng, "Location-based social networks: Users," in *Computing with spatial trajectories*, pp. 243–276, New York: Springer, 2011.
- [107] V. W. Zheng, Y. Zheng, X. Xie, and Q. Yang, "Collaborative location and activity recommendations with gps history data," in *Proceedings of the International Conference on World Wide Web*, pp. 1029–1038, 2010.
- [108] Z. Ding, X. Li, C. Jiang, and M. Zhou, "Objectives and state-of-the-art of location-based social network recommender systems," *Acm Computing Surveys (Csur)*, vol. 51, no. 1, pp. 1–28, 2018.
- [109] H. A. Rahmani, M. Aliannejadi, M. Baratchi, and F. Crestani, "Joint geographical and temporal modeling based on matrix factorization for point-of-interest recommendation," in *Proceedings of the European Conference on Information Retrieval*, pp. 205–219, Springer, 2020.
- [110] H. Yoon, Y. Zheng, X. Xie, and W. Woo, "Smart itinerary recommendation based on usergenerated gps trajectories," in *Proceedings of the International Conference on the Ubiquitous Intelligence and Computing (UIC)*, pp. 19–34, Springer, 2010.
- [111] K. Vassakis, E. Petrakis, I. Kopanakis, J. Makridis, and G. Mastorakis, "Location-based social network data for tourism destinations," *Big Data and Innovation in Tourism, Travel, and Hospitality: Managerial Approaches, Techniques, and Applications*, pp. 105–114, 2019.
- [112] I. P. Tussyadiah, "A concept of location-based social network marketing," Journal of Travel & Tourism Marketing, vol. 29, no. 3, pp. 205–220, 2012.
- [113] L. Wang, X. Geng, X. Ma, F. Liu, and Q. Yang, "Crowd flow prediction by deep spatiotemporal transfer learning," arXiv preprint arXiv:1802.00386, 2018.
- [114] I. Afyouni, A. Khan, and Z. A. Aghbari, "Deep-eware: spatio-temporal social event detection using a hybrid learning model," *Journal of Big Data*, vol. 9, no. 1, p. 86, 2022.
- [115] L. Ruan, C. Li, Y. Zhang, and H. Wang, "Soft computing model based financial aware spatiotemporal social network analysis and visualization for smart cities," *Computers, Environment and Urban Systems*, vol. 77, p. 101268, 2019.

- [116] C. Bracis, K. L. Bildstein, and T. Mueller, "Revisitation analysis uncovers spatio-temporal patterns in animal movement data," *Ecography*, vol. 41, no. 11, pp. 1801–1811, 2018.
- [117] K.-Y. Yie, T.-W. Chien, Y.-T. Yeh, W. Chou, and S.-B. Su, "Using social network analysis to identify spatiotemporal spread patterns of covid-19 around the world: online dashboard development," *International Journal of Environmental Research and Public Health*, vol. 18, no. 5, p. 2461, 2021.
- [118] W. Liu, B. Wang, Y. Yang, N. Mou, Y. Zheng, L. Zhang, and T. Yang, "Cluster analysis of microscopic spatio-temporal patterns of tourists' movement behaviors in mountainous scenic areas using open gps-trajectory data," *Tourism Management*, vol. 93, p. 104614, 2022.
- [119] M. Baratchi, N. Meratnia, and P. J. Havinga, "Finding frequently visited paths: dealing with the uncertainty of spatio-temporal mobility data," in 2013 IEEE Eighth International Conference on Intelligent Sensors, Sensor Networks and Information Processing, pp. 479– 484, IEEE, 2013.
- [120] D. B. West, Introduction to graph theory, vol. 2. London: Prentice hall Upper Saddle River, 2001.
- [121] E. W. Dijksta, "A note on two problems in connexion with graphs," *Numerische mathematik*, vol. 1, no. 1, pp. 269–271, 1959.
- [122] D. Müllner, "Modern hierarchical, agglomerative clustering algorithms," *arXiv preprint* arXiv:1109.2378, 2011.
- [123] P. J. Rousseeuw, "Silhouettes: a graphical aid to the interpretation and validation of cluster analysis," *Journal of Computational and Applied Mathematics*, vol. 20, pp. 53–65, 1987.
- [124] K. A. Clevenger, K. A. Pfeiffer, and A. L. Pearson, "Using linked accelerometer and gps data for characterizing children's schoolyard physical activity: An overview of hot spot analytic decisions with reporting guidelines," *Spatial and Spatio-temporal Epidemiology*, p. 100548, 2022.
- [125] S. Schneider, A. Bolbos, J. Fessler, and C. Buck, "Deprivation amplification due to structural disadvantage? playgrounds as important physical activity resources for children and adolescents," *Public Health*, vol. 168, pp. 117–127, 2019.
- [126] T. Caliński and J. Harabasz, "A dendrite method for cluster analysis," Communications in Statistics-theory and Methods, vol. 3, no. 1, pp. 1–27, 1974.
- [127] D. L. Davies and D. W. Bouldin, "A cluster separation measure," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, no. 2, pp. 224–227, 1979.
- [128] K. Allen, M. L. Kern, D. Vella-Brodrick, J. Hattie, and L. Waters, "What schools need to know about fostering school belonging: A meta-analysis," *Educational psychology review*, vol. 30, pp. 1–34, 2018.
- [129] H. Craggs and C. Kelly, "Adolescents' experiences of school belonging: A qualitative metasynthesis," *Journal of Youth Studies*, vol. 21, no. 10, pp. 1411–1425, 2018.
- [130] S. Ascher and J. Paquette, "Loneliness and peer relations in childhood. currents directions in psychological science, 12, 75–78," 2003.
- [131] J. T. Cacioppo, M. E. Hughes, L. J. Waite, L. C. Hawkley, and R. A. Thisted, "Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses.," *Psychology and aging*, vol. 21, no. 1, p. 140, 2006.

- [132] Z. I. Santini, V. S. Pisinger, L. Nielsen, K. R. Madsen, M. K. Nelausen, A. Koyanagi, V. Koushede, S. Roffey, L. C. Thygesen, and C. Meilstrup, "Social disconnectedness, loneliness, and mental health among adolescents in danish high schools: A nationwide crosssectional study," *Frontiers in behavioral neuroscience*, vol. 15, p. 632906, 2021.
- [133] C. Chevallier, G. Kohls, V. Troiani, E. S. Brodkin, and R. T. Schultz, "The social motivation theory of autism," *Trends in cognitive sciences*, vol. 16, no. 4, pp. 231–239, 2012.
- [134] G. Dawson, "Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder," *Development and psychopathology*, vol. 20, no. 3, pp. 775–803, 2008.
- [135] A. Klin, W. Jones, R. Schultz, and F. Volkmar, "The enactive mind, or from actions to cognition: lessons from autism," *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, vol. 358, no. 1430, pp. 345–360, 2003.
- [136] A. Deckers, P. Muris, and J. Roelofs, "Being on your own or feeling lonely? loneliness and other social variables in youths with autism spectrum disorders," *Child Psychiatry & Human Development*, vol. 48, pp. 828–839, 2017.
- [137] S. Bottini, "Social reward processing in individuals with autism spectrum disorder: A systematic review of the social motivation hypothesis," *Research in autism spectrum disorders*, vol. 45, pp. 9–26, 2018.
- [138] V. K. Jaswal and N. Akhtar, "Being versus appearing socially uninterested: Challenging assumptions about social motivation in autism," *Behavioral and Brain Sciences*, vol. 42, p. e82, 2019.
- [139] F. Rademaker, A. de Boer, E. Kupers, and A. Minnaert, "Applying the contact theory in inclusive education: A systematic review on the impact of contact and information on the social participation of students with disabilities," in *Frontiers in Education*, vol. 5, p. 602414, Frontiers Media SA, 2020.
- [140] G. W. Allport, "The nature oj'prejudice," Reading: Addison-Wesley, vol. 129, 1954.
- [141] A. Anderson, D. W. Moore, R. Godfrey, and C. M. Fletcher-Flinn, "Social skills assessment of children with autism in free-play situations," *Autism*, vol. 8, no. 4, pp. 369–385, 2004.
- [142] Y.-C. Chang, C.-H. Chen, P.-C. Huang, and L.-Y. Lin, "Understanding the characteristics of friendship quality, activity participation, and emotional well-being in taiwanese adolescents with autism spectrum disorder," *Scandinavian journal of occupational therapy*, vol. 26, no. 6, pp. 452–462, 2019.
- [143] M. Falkmer, K. Oehlers, M. Granlund, and T. Falkmer, "Can you see it too? observed and self-rated participation in mainstream schools in students with and without autism spectrum disorders," *Developmental neurorehabilitation*, vol. 18, no. 6, pp. 365–374, 2015.
- [144] J. Locke, W. Shih, M. Kretzmann, and C. Kasari, "Examining playground engagement between elementary school children with and without autism spectrum disorder," *Autism*, vol. 20, no. 6, pp. 653–662, 2016.
- [145] V. Phares, "Father absence, mother love, and other family issues that need to be questioned: Comment on silverstein (1993).," *Journal of Family Psychology*, 1993.
- [146] T. Bowles and J. Scull, "The centrality of connectedness: A conceptual synthesis of attending, belonging, engaging and flowing," *Journal of Psychologists and Counsellors in Schools*, vol. 29, no. 1, pp. 3–21, 2019.

- [147] K. Bottema-Beutel, C. Malloy, J. Cuda, S. Y. Kim, and J. P. MacEvoy, "Friendship expectations may be similar for mental age-matched children with autism spectrum disorder and typically developing children," *Journal of autism and developmental disorders*, vol. 49, pp. 4346–4354, 2019.
- [148] B. Chamberlain, C. Kasari, and E. Rotheram-Fuller, "Involvement or isolation? the social networks of children with autism in regular classrooms," *Journal of autism and developmental disorders*, vol. 37, pp. 230–242, 2007.
- [149] C. Kasari, J. Locke, A. Gulsrud, and E. Rotheram-Fuller, "Social networks and friendships at school: Comparing children with and without asd," *Journal of autism and developmental disorders*, vol. 41, pp. 533–544, 2011.
- [150] J. Locke, C. Kasari, E. Rotheram-Fuller, M. Kretzmann, and J. Jacobs, "Social network changes over the school year among elementary school-aged children with and without an autism spectrum disorder," *School Mental Health*, vol. 5, pp. 38–47, 2013.
- [151] M. Dean, C. Kasari, W. Shih, F. Frankel, R. Whitney, R. Landa, C. Lord, F. Orlich, B. King, and R. Harwood, "The peer relationships of girls with asd at school: comparison to boys and girls with and without asd," *Journal of Child Psychology and Psychiatry*, vol. 55, no. 11, pp. 1218–1225, 2014.
- [152] L. Calder, V. Hill, and E. Pellicano, "'sometimes i want to play by myself': Understanding what friendship means to children with autism in mainstream primary schools," *Autism*, vol. 17, no. 3, pp. 296–316, 2013.
- [153] S. O'Hagan and J. Hebron, "Perceptions of friendship among adolescents with autism spectrum conditions in a mainstream high school resource provision," *European Journal of Special Needs Education*, vol. 32, no. 3, pp. 314–328, 2017.
- [154] F. Sedgewick, V. Hill, R. Yates, L. Pickering, and E. Pellicano, "Gender differences in the social motivation and friendship experiences of autistic and non-autistic adolescents," *Journal of autism and developmental disorders*, vol. 46, pp. 1297–1306, 2016.
- [155] R. S. V. Foggo and A. A. Webster, "Understanding the social experiences of adolescent females on the autism spectrum," *Research in Autism Spectrum Disorders*, vol. 35, pp. 74– 85, 2017.
- [156] L. Cresswell, R. Hinch, and E. Cage, "The experiences of peer relationships amongst autistic adolescents: A systematic review of the qualitative evidence," *Research in Autism Spectrum Disorders*, vol. 61, pp. 45–60, 2019.
- [157] N. Bauminger, C. Shulman, and G. Agam, "Peer interaction and loneliness in highfunctioning children with autism," *Journal of autism and developmental disorders*, vol. 33, pp. 489–507, 2003.
- [158] J. Locke, E. H. Ishijima, C. Kasari, and N. London, "Loneliness, friendship quality and the social networks of adolescents with high-functioning autism in an inclusive school setting," *Journal of research in special educational needs*, vol. 10, no. 2, pp. 74–81, 2010.
- [159] A. J. Whitehouse, K. Durkin, E. Jaquet, and K. Ziatas, "Friendship, loneliness and depression in adolescents with asperger's syndrome," *Journal of adolescence*, vol. 32, no. 2, pp. 309– 322, 2009.
- [160] T. J. Berndt, "The features and effects of friendship in early adolescence," *Child development*, pp. 1447–1460, 1982.

- [161] C. Cattuto, W. Van den Broeck, A. Barrat, V. Colizza, J.-F. Pinton, and A. Vespignani, "Dynamics of person-to-person interactions from distributed rfid sensor networks," *PloS one*, vol. 5, no. 7, p. e11596, 2010.
- [162] L. C. Freeman et al., "Centrality in social networks: Conceptual clarification," Social network: critical concepts in sociology. Londres: Routledge, vol. 1, pp. 238–263, 2002.
- [163] J. Zhang and Y. Luo, "Degree centrality, betweenness centrality, and closeness centrality in social network," in 2017 2nd international conference on modelling, simulation and applied mathematics (MSAM2017), pp. 300–303, Atlantis press, 2017.
- [164] S. J. Pijl, P. Frostad, and A. Flem, "The social position of pupils with special needs in regular schools," *Scandinavian Journal of Educational Research*, vol. 52, no. 4, pp. 387–405, 2008.
- [165] S. R. Asher and V. A. Wheeler, "Children's loneliness: a comparison of rejected and neglected peer status.," *Journal of consulting and clinical psychology*, vol. 53, no. 4, p. 500, 1985.
- [166] M. Maes, W. Van den Noortgate, J. Vanhalst, W. Beyers, and L. Goossens, "The children's loneliness scale: Factor structure and construct validity in belgian children," *Assessment*, vol. 24, no. 2, pp. 244–251, 2017.
- [167] G. Csardi and T. Nepusz, "The igraph software," Complex syst, vol. 1695, pp. 1–9, 2006.
- [168] R. C. Team et al., "R: A language and environment for statistical computing," Foundation for Statistical Computing, Vienna, Austria, 2013.
- [169] G. Van Rossum and F. L. Drake Jr, "Python tutorial," 1995.
- [170] M. J. Azur, E. A. Stuart, C. Frangakis, and P. J. Leaf, "Multiple imputation by chained equations: what is it and how does it work?," *International journal of methods in psychiatric research*, vol. 20, no. 1, pp. 40–49, 2011.
- [171] J. L. Schafer and J. W. Graham, "Missing data: our view of the state of the art.," Psychological methods, vol. 7, no. 2, p. 147, 2002.
- [172] J. R. Van Ginkel, M. Linting, R. C. Rippe, and A. van der Voort, "Rebutting existing misconceptions about multiple imputation as a method for handling missing data," *Journal* of personality assessment, vol. 102, no. 3, pp. 297–308, 2020.
- [173] P. C. Austin and E. A. Stuart, "Moving towards best practice when using inverse probability of treatment weighting (iptw) using the propensity score to estimate causal treatment effects in observational studies," *Statistics in medicine*, vol. 34, no. 28, pp. 3661–3679, 2015.
- [174] N. C. Chesnaye, V. S. Stel, G. Tripepi, F. W. Dekker, E. L. Fu, C. Zoccali, and K. J. Jager, "An introduction to inverse probability of treatment weighting in observational research," *Clinical Kidney Journal*, vol. 15, no. 1, pp. 14–20, 2022.
- [175] C. Ruth, M. Brownell, J. Isbister, L. MacWilliam, H. Gammon, D. Singal, and E. Boreskewich, Long-term outcomes of manitoba's insight mentoring program: a comparative statistical analysis. Manitoba Centre for Health Policy Winnipeg, MB, 2015.
- [176] P. Blatchford, P. Bassett, and P. Brown, "Examining the effect of class size on classroom engagement and teacher-pupil interaction: Differences in relation to pupil prior attainment and primary vs. secondary schools," *Learning and instruction*, vol. 21, no. 6, pp. 715–730, 2011.
- [177] F. de Swart, W. J. Burk, W. B. Nelen, and R. H. Scholte, "Peer preference, perceived popularity, and the teacher-child relationship in special education," *Remedial and Special Education*, vol. 42, no. 2, pp. 67–77, 2021.

- [178] K. L. Lane, J. H. Wehby, M. A. Little, and C. Cooley, "Academic, social, and behavioral profiles of students with emotional and behavioral disorders educated in self-contained classrooms and self-contained schools: Part i—are they more alike than different?," *Behavioral Disorders*, vol. 30, no. 4, pp. 349–361, 2005.
- [179] L. Sokal and U. Sharma, "Canadian in-service teachers' concerns, efficacy, and attitudes about inclusive teaching," *Exceptionality Education International*, vol. 23, no. 1, 2014.
- [180] L. Florian, "Reimagining special education: Why new approaches are needed," The SAGE handbook of special education, vol. 1, pp. 9–22, 2014.
- [181] C. Rieffe and A. Koutamanis, "Een autisme-vriendelijke school: Architectuur als eerste stap," Wetenschappelijk Tijdschrift Autisme, vol. 22, no. 4, pp. 29–39, 2023.
- [182] M. Mostafa, "Architecture for autism: Autism aspectss[™] in school design," International Journal of Architectural Research: ArchNet-IJAR, vol. 8, no. 1, pp. 143–158, 2014.
- [183] K. Harris, P. Rosinski, J. Wood-Nartker, and R. Hill Renirie, "Developing inclusive playgrounds that welcome all children—including those with autism," *Review Journal of Autism* and Developmental Disorders, pp. 1–9, 2022.
- [184] N. Yuill, S. Strieth, C. Roake, R. Aspden, and B. Todd, "Brief report: Designing a playground for children with autistic spectrum disorders—effects on playful peer interactions," *Journal* of autism and developmental disorders, vol. 37, pp. 1192–1196, 2007.
- [185] M. H. Black, R. Kuzminski, J. Wang, J. Ang, C. Lee, S. Hafidzuddin, and S. McGarry, "Experiences of friendships for individuals on the autism spectrum: A scoping review," *Review Journal of Autism and Developmental Disorders*, pp. 1–26, 2022.
- [186] B. A. Corbett, D. M. Swain, C. Newsom, L. Wang, Y. Song, and D. Edgerton, "Biobehavioral profiles of arousal and social motivation in autism spectrum disorders," *Journal of child psychology and psychiatry*, vol. 55, no. 8, pp. 924–934, 2014.
- [187] M. Dean, R. Harwood, and C. Kasari, "The art of camouflage: Gender differences in the social behaviors of girls and boys with autism spectrum disorder," *Autism*, vol. 21, no. 6, pp. 678–689, 2017.
- [188] A. Mannion and G. Leader, "Comorbidity in autism spectrum disorder: A literature review," *Research in Autism Spectrum Disorders*, vol. 7, no. 12, pp. 1595–1616, 2013.
- [189] E. Holmes and T. Willoughby, "Play behaviour of children with autism spectrum disorders," Journal of Intellectual and Developmental Disability, vol. 30, no. 3, pp. 156–164, 2005.
- [190] K. S. Gunn, D. Trembath, and K. Hudry, "An examination of interactions among children with autism and their typically developing peers," *Developmental Neurorehabilitation*, vol. 17, no. 5, pp. 327–338, 2014.
- [191] D. UNICEF et al., "Seen, counted, included: Using data to shed light on the well-being of children with disabilities," New York: United Nations Children's Fund, 2021.
- [192] A. Ermagun and D. Levinson, "Spatiotemporal traffic forecasting: review and proposed directions," *Transport Reviews*, vol. 38, no. 6, pp. 786–814, 2018.
- [193] Y. Chang, J. Qi, Y. Liang, and E. Tanin, "Contrastive trajectory similarity learning with dual-feature attention," in 2023 IEEE 39th International Conference on Data Engineering (ICDE), pp. 2933–2945, IEEE, 2023.
- [194] D. Yao, C. Zhang, Z. Zhu, J. Huang, and J. Bi, "Trajectory clustering via deep representation learning," in 2017 international joint conference on neural networks (IJCNN), pp. 3880–3887, IEEE, 2017.

- [195] X. Li, K. Zhao, G. Cong, C. S. Jensen, and W. Wei, "Deep representation learning for trajectory similarity computation," in 2018 IEEE 34th international conference on data engineering (ICDE), pp. 617–628, IEEE, 2018.
- [196] L. Liu, J. Zhen, G. Li, G. Zhan, Z. He, B. Du, and L. Lin, "Dynamic spatial-temporal representation learning for traffic flow prediction," *IEEE Transactions on Intelligent Transportation Systems*, vol. 22, no. 11, pp. 7169–7183, 2020.
- [197] S. Dabiri, C.-T. Lu, K. Heaslip, and C. K. Reddy, "Semi-supervised deep learning approach for transportation mode identification using gps trajectory data," *IEEE Transactions on Knowledge and Data Engineering*, vol. 32, no. 5, pp. 1010–1023, 2019.
- [198] T.-Y. Fu and W.-C. Lee, "Trembr: Exploring road networks for trajectory representation learning," ACM Transactions on Intelligent Systems and Technology (TIST), 2020.
- [199] J. Jiang, D. Pan, H. Ren, X. Jiang, C. Li, and J. Wang, "Self-supervised trajectory representation learning with temporal regularities and travel semantics," in 2023 IEEE 39th international conference on data engineering (ICDE), IEEE, 2023.
- [200] X. Liu, Y. Liang, C. Huang, Y. Zheng, B. Hooi, and R. Zimmermann, "When do contrastive learning signals help spatio-temporal graph forecasting?," in *Proceedings of the 30th International Conference on Advances in Geographic Information Systems*, pp. 1–12, 2022.
- [201] Z. Fan, X. Song, Q. Chen, R. Jiang, R. Shibasaki, and K. Tsubouchi, "Trajectory fingerprint: one-shot human trajectory identification using siamese network," *CCF Transactions* on *Pervasive Computing and Interaction*, vol. 2, no. 2, pp. 113–125, 2020.
- [202] F. Schroff, D. Kalenichenko, and J. Philbin, "Facenet: A unified embedding for face recognition and clustering," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 815–823, 2015.
- [203] A. v. d. Oord, Y. Li, and O. Vinyals, "Representation learning with contrastive predictive coding," arXiv preprint arXiv:1807.03748, 2018.
- [204] J. Bromley, J. W. Bentz, L. Bottou, I. Guyon, Y. LeCun, C. Moore, E. Säckinger, and R. Shah, "Signature verification using a "siamese" time delay neural network," *International Journal of Pattern Recognition and Artificial Intelligence*, vol. 7, no. 04, 1993.
- [205] A. Yan, S. Cheng, W.-C. Kang, M. Wan, and J. McAuley, "Cosrec: 2d convolutional neural networks for sequential recommendation," in *Proceedings of the 28th ACM international* conference on information and knowledge management, 2019.
- [206] J.-F. Chen, W.-L. Chen, C.-P. Huang, S.-H. Huang, and A.-P. Chen, "Financial time-series data analysis using deep convolutional neural networks," in 2016 7th International conference on cloud computing and big data (CCBD), pp. 87–92, IEEE, 2016.
- [207] Y. Sun, C. Cheng, Y. Zhang, C. Zhang, L. Zheng, Z. Wang, and Y. Wei, "Circle loss: A unified perspective of pair similarity optimization," in *Proceedings of the IEEE/CVF* conference on computer vision and pattern recognition, 2020.
- [208] F. Wilcoxon, "Individual comparisons by ranking methods. biometrics bulletin. 1945; 1 (6): 80–83," International Biometric Society, Wiley, US, 2012.
- [209] S. Pellegrini, A. Ess, K. Schindler, and L. Van Gool, "You'll never walk alone: Modeling social behavior for multi-target tracking," in 2009 IEEE 12th International Conference on Computer Vision, pp. 261–268, IEEE, 2009.

- [210] A. Lerner, Y. Chrysanthou, and D. Lischinski, "Crowds by example," in *Computer graphics forum*, vol. 26, pp. 655–664, Wiley Online Library, 2007.
- [211] A. Strehl and J. Ghosh, "Cluster ensembles—a knowledge reuse framework for combining multiple partitions," *Journal of machine learning research*, vol. 3, no. Dec, 2002.
- [212] E. B. Fowlkes and C. L. Mallows, "A method for comparing two hierarchical clusterings," *Journal of the American statistical association*, vol. 78, no. 383, pp. 553–569, 1983.
- [213] J. MacQueen et al., "Some methods for classification and analysis of multivariate observations," in Proceedings of the fifth Berkeley symposium on mathematical statistics and probability, vol. 1, pp. 281–297, Oakland, CA, USA, 1967.
- [214] P. Khosla, P. Teterwak, C. Wang, A. Sarna, Y. Tian, P. Isola, A. Maschinot, C. Liu, and D. Krishnan, "Supervised contrastive learning," *Advances in neural information processing* systems, vol. 33, pp. 18661–18673, 2020.
- [215] J.-Y. Franceschi, A. Dieuleveut, and M. Jaggi, "Unsupervised scalable representation learning for multivariate time series," *Advances in neural information processing systems*, vol. 32, 2019.
- [216] J. Juvonen, L. M. Lessard, R. Rastogi, H. L. Schacter, and D. S. Smith, "Promoting social inclusion in educational settings: Challenges and opportunities," *Educational Psychologist*, vol. 54, no. 4, pp. 250–270, 2019.
- [217] M. F. Hazlehurst, K. L. Wolf, C. Simmons, C. Nieto, M. K. Steiner, K. A. Garrett, A. V. Faino, M. Ubalde López, M. López-Toribio, and P. S. Tandon, "Physical activity and social interaction assessments in schoolyard settings using the system for observing outdoor play environments in neighborhood schools (soopen)," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 20, no. 1, p. 94, 2023.
- [218] J. Stehlé, N. Voirin, A. Barrat, C. Cattuto, L. Isella, J.-F. Pinton, M. Quaggiotto, W. Van den Broeck, C. Régis, B. Lina, *et al.*, "High-resolution measurements of face-to-face contact patterns in a primary school," *PloS one*, vol. 6, no. 8, p. e23176, 2011.
- [219] M. Hoffman, P. Block, T. Elmer, and C. Stadtfeld, "A model for the dynamics of face-to-face interactions in social groups," *Network Science*, vol. 8, no. S1, pp. S4–S25, 2020.
- [220] X. Que, F. Checconi, F. Petrini, and J. A. Gunnels, "Scalable community detection with the louvain algorithm," in 2015 IEEE international parallel and distributed processing symposium, pp. 28–37, IEEE, 2015.
- [221] J. Yang, J. McAuley, and J. Leskovec, "Community detection in networks with node attributes," in 2013 IEEE 13th international conference on data mining, pp. 1151–1156, IEEE, 2013.
- [222] V. D. Blondel, J.-L. Guillaume, R. Lambiotte, and E. Lefebvre, "Fast unfolding of communities in large networks," *Journal of Statistical Mechanics: Theory and Experiment*, vol. 2008, no. 10, p. P10008, 2008.
- [223] F. Solera, S. Calderara, and R. Cucchiara, "Socially constrained structural learning for groups detection in crowd," *IEEE Transactions on Pattern Analysis and Machine Intelli*gence, vol. 38, no. 5, pp. 995–1008, 2015.
- [224] K. Yamaguchi, A. C. Berg, L. E. Ortiz, and T. L. Berg, "Who are you with and where are you going?," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pp. 1345–1352, IEEE, 2011.

- [225] M. Swofford, J. Peruzzi, N. Tsoi, S. Thompson, R. Martín-Martín, S. Savarese, and M. Vázquez, "Improving social awareness through dante: Deep affinity network for clustering conversational interactants," *Proc. ACM Hum.-Comput. Interact.*, vol. 4, may 2020.
- [226] T. Kipf, E. Fetaya, K.-C. Wang, M. Welling, and R. Zemel, "Neural relational inference for interacting systems," in *Proceedings of the International Conference on Machine Learning*, pp. 2688–2697, PMLR, 2018.
- [227] T. Fernando, S. Denman, S. Sridharan, and C. Fookes, "Gd-gan: Generative adversarial networks for trajectory prediction and group detection in crowds," in *Computer Vision–* ACCV 2018: 14th Asian Conference on Computer Vision, Perth, Australia, December 2–6, 2018, Revised Selected Papers, Part I 14, pp. 314–330, Springer, 2019.
- [228] J. Li, R. Han, H. Yan, Z. Qian, W. Feng, and S. Wang, "Self-supervised social relation representation for human group detection," in *European Conference on Computer Vision*, pp. 142–159, Springer, 2022.
- [229] M. Nasri, Z. Fang, M. Baratchi, G. Englebienne, S. Wang, A. Koutamanis, and C. Rieffe, "A gnn-based architecture for group detection from spatio-temporal trajectory data," in *Advances in Intelligent Data Analysis XXI* (B. Crémilleux, S. Hess, and S. Nijssen, eds.), (Cham), pp. 327–339, Springer Nature Switzerland, 2023.
- [230] S. Thompson, A. Gupta, A. W. Gupta, A. Chen, and M. Vázquez, "Conversational group detection with graph neural networks," in *Proceedings of the International Conference on Multimodal Interaction*, pp. 248–252, 2021.
- [231] A. v. d. Oord, S. Dieleman, H. Zen, K. Simonyan, O. Vinyals, A. Graves, N. Kalchbrenner, A. Senior, and K. Kavukcuoglu, "Wavenet: A generative model for raw audio," arXiv preprint arXiv:1609.03499, 2016.
- [232] X. Lu, X. Li, C. Hu, J. Deng, W. Sheng, and L. Zhu, "A two-branch deep learning with spatial and pose constraints for social group detection," *Engineering Applications of Artificial Intelligence*, vol. 124, p. 106583, 2023.
- [233] H. Hung and B. Kröse, "Detecting f-formations as dominant sets," in *Proceedings of the* 13th International Conference on Multimodal Interfaces, ICMI '11, (New York, NY, USA), p. 231–238, Association for Computing Machinery, 2011.
- [234] J. Amirian, B. Zhang, F. V. Castro, J. J. Baldelomar, J.-B. Hayet, and J. Pettre, "Opentraj: Assessing prediction complexity in human trajectories datasets," in Asian Conference on Computer Vision (ACCV), Springer, 2020.
- [235] F. Solera, S. Calderara, and R. Cucchiara, "Socially constrained structural learning for groups detection in crowd," *IEEE Transactions on Pattern Analysis and Machine Intelli*gence, vol. 38, no. 5, pp. 995–1008, 2016.
- [236] M. Vilain, J. D. Burger, J. Aberdeen, D. Connolly, and L. Hirschman, "A model-theoretic coreference scoring scheme," in Sixth Message Understanding Conference (MUC-6): Proceedings of a Conference Held in Columbia, Maryland, November 6-8, 1995, 1995.
- [237] T. Fernando, S. Denman, S. Sridharan, and C. Fookes, "Gd-gan: Generative adversarial networks for trajectory prediction and group detection in crowds," in *Computer Vision – ACCV 2018* (C. V. Jawahar, H. Li, G. Mori, and K. Schindler, eds.), (Cham), pp. 314–330, Springer International Publishing, 2019.
- [238] I. Bae, J.-H. Park, and H.-G. Jeon, "Learning pedestrian group representations for multimodal trajectory prediction," in *European Conference on Computer Vision*, pp. 270–289, Springer, 2022.

- [239] R. F. Woolson, "Wilcoxon signed-rank test," Wiley encyclopedia of clinical trials, pp. 1–3, 2007.
- [240] B. R. Fajen, M. A. Riley, and M. T. Turvey, "Information, affordances, and the control of action in sport," *international Journal of sport psychology*, vol. 40, no. 1, pp. 79–107, 2008.

Acknowledgments

I want to express my deepest gratitude to all those who have contributed to completing this dissertation.

First and foremost, I want to express my appreciation to all the children, parents, teachers, and schools who participated in and contributed their time to this research. Without their cooperation, this work would not have been possible.

I am thankful to my supervisors, Prof.dr. Carolien Rieffe, Dr. Mitra Baratchi, and Dr. Alexander Koutamanis, for giving me the opportunity to do this multidisciplinary research. Carolien, thank you for all the opportunities you have given me and your invaluable insights into various topics and many life lessons. Mitra, your knowledge and all the excellent discussions on our analyses always provide me with refreshing thoughts. Thanks for your unwavering guidance and patience throughout all my research papers. Alexander, I have learned a lot from our Monday afternoon meetings, from the world of affordances to all the life lessons. Thanks for all your guidance throughout my PhD journey. I am also thankful to Prof.dr. Sarah Giest for her contribution and input to my research.

I am grateful to my friends and colleagues at the Focus on Emotions lab for all their support, lunchtime, and lab meeting discussions. Yung-Ting, Boya, Brenda, Jiyain, Kexin, Claudia, Meng Qi, Zijian, Shannon, Lisa, Charlotte, and Lia, I have learned a lot from each one of you. Yung-Ting, talking to you and discussing my struggles and uncertainties was always helpful. Thanks for always being there. Thanks to Nina, Iris, and Chang for being the best office mates and making all the pleasant memories on Tuesdays. My paranymphs, Kexin and Claudia, thank you for helping me organize the defense ceremony.

Thanks to all my friends in the Netherlands, Haleh Hayati, Majid Ghorbani, Sa-

har Safarloo, Abbas Jamali, Sahar Hosseini, Amirreza Yousefzadeh, Zahra Forouzi, Amirabbas Kashi, little Ario, Farimah Ghassemi, Mehdi Karamzadeh, Faezeh Kardan, Babak Mohammadi, Parisa Ghanooni, Hadi Balaghi, Sanaz Lari, Parastoo, Morteza Moradi, Parvin Kolahkaj, and Ahmad Hadi, who made me feel at home with all Shelem nights, volleyball evenings and campings.

Thanks to all my old friends, Zahra Alipour, Yalda Foroutan, Anahita Baninajar, Setareh Rahimi, and Mahsa Khosravi, for your support, no matter the distance between us now.

Thanks to my mother-in-law and father-in-law, Fati and Reza, sisters-in-law Elnaz and Anahita, brother-in-law Arash, and sweet nephew-in-law Adrian for all your encouragement throughout this journey.

My sincere gratitude goes to my family for their belief in me. Thanks, Baba and Maman, for always having my back in all my decisions. Your love and support have been my pillars of strength. My beloved sister, Mahsa, and my brother-in-law, Hanif, thank you for always supporting me at every stage, and my sweet little niece, Waniya, for bringing joy and happiness into our lives.

Ashkan, my husband and multi-aspect life partner, it would have been impossible without you. Thanks for all your love, support, and guidance.

Thanks to everyone who stood part of this academic journey and supported me in reaching this significant milestone.

Maedeh Nasri, Leiden, June 2024.

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