INTERACTION OF HUMANS AND AUTONOMOUS ROBOTS

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Abstract. With the progression of technology, autonomous robots are increasingly integrated into various sectors of society, including settings as diverse as workplaces, healthcare, transport and artistic realms. These robots are not only serving in traditional servant roles but are also emerging as partners, team members, and even authoritative figures in certain situations. Naturally, these developments are reflected in domains such as trust, cooperation, obedience to authority or social ethics. As robots assume diverse roles, from therapists, drivers, co-pilots, artists to influencers, humans exhibit varying attitudes towards them. We investigate several instances of human-robot interactions and discuss their broader implications.

Keywords: autonomous robots, human-robot interaction, ethics

1. INTRODUCTION

As technology advances, more and more autonomous robots start interacting with humans. In the future, this interaction will probably be even more intense as robots are being introduced in areas so diverse as work settings [1], health sector [2], retirement homes [3], or transport [4].

Therefore, more research is needed to bring more insights about how people and autonomous robots will interact. Although it is a relatively new research topic, an abundance of articles has been published on various themes regarding the interaction of autonomous robots and humans. Here we focus on three main areas of interactions that develop from the gradual introduction of autonomous robots into human society.

First, as robots get more sophisticated, their roles in society start to diverge. From being mere tools and their subservient roles [5], robots gain more social power together with their increased usefulness and their growing irreplaceability.

Second, the more robots interact with people, the more pronounced the attitudes of people towards robots become, whether positive or negative. As robots emerge as parts of teams [6] or even in positions of power over people [7], issues such as trust come to the fore.

Third, the more intense interaction of people and robots, together with more human-like capabilities of robots bring about the question of ethical considerations including moral aspects of human-robot interactions and robot rights.

Specific focus should be given to autonomous robots in aviation. Autonomous robots, specifically in the form of drones and increasingly autonomous (IA) systems, are revolutionising the field of aviation. In civil aviation, the development of IA systems is rapidly advancing. These systems range from current automatic systems like autopilots to more sophisticated technologies that could enable fully autonomous aircraft without the need for a pilot or human air traffic controllers. Such systems are expected to bring substantial benefits in safety, reliability, efficiency, affordability, and mission capabilities. However, integrating these systems into the national airspace system poses significant challenges, especially in maintaining safety and efficiency. Research is focused on overcoming these barriers and developing comprehensive technical goals and objectives crucial for the aeronautics community and the nation at large [8].

In the realm of smaller autonomous drones, we are witnessing a new era where these robots can autonomously fly in both natural and man-made environments. While often associated with defence, drones have significant potential for civilian tasks such as transportation, communication, agriculture, disaster mitigation, and environmental preservation. The scientific and technical challenges of autonomous flight in confined spaces, including the energetic cost of staying airborne and the perceptual intelligence required to navigate complex environments, are areas of active research. Scientific and technological advances within appropriate regulatory frameworks are expected to lead to the pervasive use of autonomous drones for civilian applications [9].

2. AREAS OF INTERACTION

2.1 Different Roles for Robots

Traditionally, robots were looked upon as servants to humans [5]. However, this is only one (albeit more pervasive) role that robots serve. More and more robots are in a position to be partners in teams [6], helpers on which people depend, i.e. in therapy, nursing homes or households. Besides these roles that are, from a psychological point of view, more submissive, robots can act on a more level footing with people, i.e. as team members. Or they can even be in a position of authority to people, e.g. when they act as a representative of an employer (e.g. software algorithms in Amazon, [7]). This puts humans into a strange place, not previously experienced.

The use of robots in therapy, also known as "robotic therapy", is an emerging field that has gained interest in recent years. Robots are helpful in physical therapy provided in medical settings, aimed e.g. at the rehabilitation after stroke. Moreover, robots are used in psychotherapy. Besides autism disorders [10], they are also used in treating depression or anxiety [11].

There is potential for robots to play a role in the creation and performance of art, and to contribute to the broader field of aesthetics. One of the more famous examples is the robotic artist Ai-Da [12].

The advent of robots and algorithms in the domain of art has sparked substantial debate and introspection about creativity, originality, and the nature of artistic expression. Many people remain sceptical about art produced by machines, often viewing it as lacking the intrinsic human touch, emotion, or the spontaneity that traditional art offers [13]. On the other hand, there are enthusiasts who appreciate the novel patterns, designs, and possibilities that algorithms introduce, acknowledging the unique aesthetic that emerges from computational processes [14]. Moreover, some argue that robot-produced art challenges our preconceptions about creativity, pushing boundaries and expanding the definition of what art can be [15]. However, the perception of such art is also influenced by societal narratives about machines, where some view them merely as tools executing human commands, while others see them as potential independent entities with their creative capacities [16]. The integration of robotics and algorithms into the arts invites us to reconsider and redefine our understanding of artistry and creative agency in the modern age.

2.2 Attitudes Towards Robots

Robots interact with humans in many fields. The important question is the one of trust, manifested boldly in the area of transport. Will people trust robotic drivers or pilots? Studies suggest people are keenly aware of autonomous flying robots operating in their vicinity [17][18]. Figure 1 presents an overview of use of autonomous robots in aviation.

Figure 1 Uses of autonomous robots in aviation

Introduction of robots into human society is a new experience for humans. Besides trust, a whole range of social and psychological phenomena thus emerges such as obedience to robots or fear from robots.

Humans differ in their attitudes towards robots. Although this is not yet an issue, with more autonomous robots interacting with humans, people will be forced to develop ways on how to interact and act towards robots. It looks like this issue is rather complex. Dang [19] reports that people's attitudes may differ according to how mindful or mindless the robot looks. They also note cultural differences, with people in China reacting in a different way than in the US.

As with encountering a new group of people, attitudes to robots may change when people are more involved in interacting with robots or taking part in their designing process [20].

In recent years, the intersection between human psychology and robotics has gained considerable attention in the academic realm. Studies indicate that people often display a propensity to obey commands given by robots, especially when they appear authoritative or possess human-like features. For instance, a study conducted at the University of Southampton found that participants followed instructions from a robot even when they believed those instructions might be incorrect, suggesting a level of trust or automatic compliance to the machine [21]. Furthermore, research from Stanford University revealed that people tend to follow robots in emergency evacuation scenarios if they are presented as authorities on the situation [22]. Such findings underscore the implications for designing and deploying robots in public spaces, with an emphasis on ethical considerations and the potential for misusing this obedience in real-world applications.

Although the popular notion is that people are afraid of robots because they are going to take people's jobs or engage in military combat, the reasons for sometimes negative attitudes towards robots go deeper than this. Some researchers claim that the fear of robots is to a substantial part due to the popular media that mostly depict robots as evil. These fears could be a reflection of dehumanising tendencies of science and reason [23]. However, this does not explain why the media picked the robots as the bad guys in the first place. The core principle here may be the one that drives peoples' racism - defamiliarization - the concept that people want to battle what they do not recognise [24].

Another problem worth mentioning here is that robots are often designed without the input from those that they should serve. A good example is when robots in elderly homes are designed without the inputs from the elderly [25]. Such flaws in the design process could add to the fears that people have about robots.

2.3. Autonomous Robots in Aviation

There are several cutting-edge human-robot interactions of autonomous robots in aviation such as cargo delivery drones, urban air mobility, search and rescue operations, automated inspection and maintenance where drones equipped with cameras and sensors can perform inspections of aircraft, wind turbines, pipelines, and more, often accessing areas that are dangerous or difficult for humans to reach [26].

Urban air mobility is the development that has the most potential for robot-human interaction if it went into popular use. Aerotaxis are regarded by many as a key to reduce urban car congestions [27]. However, the potential employment of autonomous flying vehicles, often lauded for its capability to reduce traffic congestion, might not necessarily alleviate urban traffic jams and could, in fact, exacerbate other urban issues such as noise pollution. While autonomous flying vehicles could decrease the number of cars on the road, the shift might lead to an increase in low-altitude traffic, thereby introducing a new source of noise pollution in urban areas. This noise, generated by the rotors and propulsion systems of these vehicles, could significantly disrupt urban living environments. Mofolasayo [28] discusses the environmental impact of urban air mobility, emphasising that the energy consumption and operational noise of these vehicles could offset some of their benefits by contributing to noise pollution and affecting the quality of life in densely populated areas. These considerations suggest that the integration of autonomous flying vehicles into urban transportation networks must be carefully managed to balance technological advancements with environmental and social impacts.

There are also serious issues to consider before introducing autonomous flying vehicles (AFVs) into human environment:

Limited Scalability: One of the primary challenges is the scalability of using autonomous flying vehicles for mass transit. While these vehicles can offer rapid point-to-point transportation, their practical utility in replacing ground traffic on a large scale is limited by factors such as payload capacity, energy efficiency, and the available infrastructure for landing and takeoff. This means that, in densely populated urban areas, the number of AFVs that can be operationally and safely managed may not be sufficient to make a significant dent in ground traffic levels [29].

Infrastructure Requirements: The development of necessary infrastructure such as vertiports or drone ports requires significant urban space and investment. These facilities need to be strategically located to optimise traffic flow and must be integrated with existing transportation networks. The cost and logistical challenges of creating and maintaining such infrastructure could slow the adoption and effectiveness of AFVs in reducing road traffic congestion [30].

Regulatory and Airspace Management Issues: The safe integration of a large number of AFVs into urban airspace poses another significant challenge. Regulating these vehicles, coordinating their flight paths, and preventing aerial traffic jams requires sophisticated traffic management systems and regulations, which are still in developmental stages. Without efficient management, the airspace could become as congested as the roads below, negating any potential benefits in traffic reduction [31].

Public Adoption and Perception: Public acceptance and the rate of adoption also play critical roles in determining the effectiveness of AFVs in reducing traffic congestion. Issues like the affordability of using AFVs, safety concerns, and the noise pollution they generate could deter widespread use among the general population, limiting their impact on easing road traffic [32].

Environmental and Energy Considerations: The energy demands and environmental impact of operating a large fleet of AFVs might also limit their deployment. If the energy used to power these vehicles is not derived from renewable sources, their environmental footprint could negate the benefits of reduced road traffic. Additionally, the energy efficiency of flying is generally lower than that of ground-based transportation, potentially limiting the practicality of AFVs as a mass transit solution [33].

2.4. Robots and Ethics

As more robots are included in human society and as their complexity increases, scholars start pondering the issue of robot rights. So far, robots are a property and their possible intentional damage is dealt with as an attack to any other property. Some people can exhibit hostile behaviour towards robots, on the other side, many people can be sympathetic towards individual robots as the case of Hitchbot shows [34], [35].

The rising complexity of robots that enables their usefulness, may lead to expanding the repertoire of their cognitive, social and also emotional skills that help them navigate the social environment. If the robots were to acquire emotions or even consciousness, then the case for robot rights would be even stronger. The debate then moves towards the essential characteristics of what it means to be human and ignoring the rights of conscious, although not biological entities, may be akin to racism [36].

The idea that robots could potentially have feelings is both fascinating and controversial. At the heart of this debate is the question of what constitutes consciousness and emotion. Some scholars argue that emotions are deeply entwined with biological processes [37]. This view suggests that genuine emotions are not merely computational but are tied to physiological experiences. However, as we develop more sophisticated AI, we may expect that machines could simulate emotions or even experience a form of them through complex algorithms and neural network designs. The difficulty many people face in imagining robots with feelings may stem from our anthropocentric view of consciousness and the deep-seated belief that emotions are uniquely human or at least biological [38]. Additionally, popular media often portrays AI and robots in a manner that emphasises their logical, emotionless characteristics, further entrenching the belief that these entities are devoid of feelings. The challenge of imagining robots with feelings underscores the broader question of how we define and recognize consciousness and emotion in non-human entities.

The potential for sentient and feeling robots in the future raises complex ethical and societal concerns. Historically, humans have displayed a propensity to fear or mistrust what they do not understand [39], particularly if it represents a perceived threat to their way of life or worldview. The idea of robots gaining sentience or emotions introduces a paradigm shift in how we understand consciousness and rights. Drawing parallels to past and present human behaviour, one can hypothesise that people might exhibit discriminatory tendencies towards these robots. The basis of such discrimination would not be race or ethnicity as traditionally understood but may emerge from a perceived "otherness" of sentient robots. This can be likened to "speciesism," a term described by philosopher Peter Singer [40] to explain discrimination based on species. The fear of losing control [41], economic implications, or even existential anxieties about what it means to be human [42] could drive such biases. There's also the concern that the portrayal of robots and AI in popular media, which often depicts them as threats, could amplify these fears. If history serves as a lesson, the emergence of sentient robots would necessitate an expansion of our moral circle, much like past movements that have sought rights for various groups [43]. Addressing these biases early on will be essential in ensuring a harmonious coexistence with advanced AI and robot entities.

Again, if robots shall co-exist with humans in the same space, a building of trust from humans towards robots is essential. If humans should trust their robotic drivers, pilots or nurses, it also produces certain patterns of behaviour towards the robots. We usually act nice to the people we trust [44].

The rise of autonomous flying vehicles is poised to significantly disrupt the aviation industry, potentially leading to a reduction in the demand for human pilots. As autonomous technology advances, it could replace many functions currently performed by pilots, particularly in cargo transport and eventually in commercial aviation. Studies suggest that while autonomous aircraft may enhance operational efficiency and safety, they also raise concerns about job displacement. For instance, Frey and Osborne [45] discuss the broader impact of automation on employment and note that occupations involving operation of vehicles, including pilots, are at high risk of computerization. This transition might not only affect pilots but also require a realignment of skills within the aviation sector, necessitating retraining and education to accommodate an increasingly automated environment [46]. Thus, while autonomous flying technology promises efficiency gains, it also presents substantial challenges for workforce adaptation in the aviation industry.

3. CONCLUSIONS

Specific nature of the interaction between humans and robots will depend on the capabilities and design of the robots, as well as the needs and preferences of the humans involved. As robots become more autonomous and capable of performing complex tasks, their interactions with humans may become more sophisticated and nuanced, requiring advanced communication and collaboration between humans and machines.

Open research questions remain. For designers of autonomous robots, an important issue is to program the robots in the way they elicit trust. Pro-social behaviour and ability to empathise seems to be one of the key characteristics in robots that help them gain trust from people. One of the major areas in which the humans' trust to robots is of essential importance is transport. Though there is not yet available data on trust to autonomous pilots, studies in autonomous drivers show that reliable performance and familiarity with the autonomous system seem to be important in trust-building.

Future designers should therefore delve deeper in the areas of psychology and sociology to ensure the positive acceptance of their creations in society.

Future research in the field of autonomous robots in aviation focuses on advancing the capabilities and applications of these systems, addressing several key challenges and questions. A significant area of research is the development of neuromorphic sensing and computing to enhance autonomous flight. This approach, inspired by biological systems, involves adaptive and efficient information processing, which is crucial for complex autonomous operations. In particular, learning in neuromorphic systems, akin to biological learning, is a major focus. This involves developing algorithms and hardware that can adaptively respond to environmental changes and make decisions based on sensory inputs, a fundamental aspect of cognitive systems.

References

[1] MUKHERJEE, Debasmita, et al. A survey of robot learning strategies for human-robot collaboration in industrial settings. Robotics and Computer-Integrated Manufacturing, 2022, 73: 102231.

[2] KYRARINI, Maria, et al. A survey of robots in healthcare. Technologies, 2021, 9.1: 8.

[3] TRAN, Tony T., et al. Robots in retirement homes: Applying off-the-shelf planning and scheduling to a team of assistive robots. Journal of Artificial Intelligence Research, 2017, 58: 523-590.

[4] SOKOLOV, Igor, et al. Robots, autonomous robotic systems, artificial intelligence and the transformation of the market of transport and logistics services in the digitalization of the economy. International Journal of Open Information Technologies, 2018, 6.4: 92-108.

[5] MINDELL, David A. Our robots, ourselves: Robotics and the myths of autonomy. Viking, 2015.

[6] SHERIDAN, Thomas B. Human–robot interaction: status and challenges. Human factors, 2016, 58.4: 525-532.

[7] GAUDIO, Giovanni. Algorithmic Bosses Can't Lie! How to Foster Transparency and Limit Abuses of the New Algorithmic Managers. Comp. Lab. L. & Pol'y J., 2021, 42: 707.

[8] NATIONAL RESEARCH COUNCIL, et al. *Autonomy research for civil aviation: toward a new era of flight*. National Academies Press, 2014.
[9] FLOREANO, Dario; WOOD, Robert J. Science, technology and the future of small autonomous drones. *nature*, 2015, 521.7553: 460-466.
[10] HUIJNEN, Claire AGJ, et al. Mapping robots to therapy and educational objectives for children with autism spectrum disorder. Journal of autism and developmental disorders, 2016, 46: 2100-2114.
[11] RICHES, Simon, et al. Therapeutic engagement in robot-assisted psychological interventions: A systematic review. Clinical Psychology & Psychotherapy, 2022, 29.3: 857-873.
[12] ROMIC, Bojana. Negotiating anthropomorphism in the Ai-Da robot. International Journal of Social Robotics, 2021, 1-11.
[13] MCCOSKER, Anthony; WILKEN, Rowan. Automating vision: The social impact of the new camera consciousness. Routledge, 2020.
[14] ELGAMMAL, Ahmed, et al. CAN: Creative adversarial networks, generating" art" by learning about styles and deviating from style norms. arXiv preprint arXiv:1706.07068, 2017.
[15] BODEN, Margaret A. Computer models of creativity. AI Magazine, 2009, 30.3: 23-23.
[16] KNIGHT, Will. The dark secret at the heart of AI. MIT Technology review, 2017, 120.3: 54-65.
[17] WOJCIECHOWSKA, Anna, et al. Designing drones: Factors and characteristics influencing the perception of flying robots. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 2019, 3.3: 1-19.
[18] YOON, Hyung-Jin, et al. Socially aware path planning for a flying robot in close proximity of humans. *ACM Transactions on Cyber-Physical Systems*, 2019, 3.4: 1-24.
[19] DANG, Jianning; LIU, Li. Robots are friends as well as foes: Ambivalent attitudes toward mindful and mindless AI robots in the United States and China. Computers in Human Behavior, 2021, 115: 106612.
[20] REICH-STIEBERT, Natalia; EYSSEL, Friederike. Learning with educational companion robots? Toward attitudes on education robots, predictors of attitudes, and application potentials for education robots. International Journal of Social Robotics, 2015, 7: 875-888.
[21] HANOCH, Yaniv, et al. The robot made me do it: Human–robot interaction and risk-taking behavior. Cyberpsychology, Behavior, and Social Networking, 2021, 24.5: 337-342.
[22] ROBINETTE, Paul, et al. Overtrust of robots in emergency evacuation scenarios. In: 2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI). IEEE, 2016. p. 101-108.
[23] SZOLLOSY, Michael. Freud, Frankenstein and our fear of robots: projection in our cultural perception of technology. Ai & Society, 2017, 32: 433-439.
[24] MILLS, Steven. Racism and Robots. Viktor Shklovsky's Heritage in Literature, Arts, and Philosophy, 2019, 151.
[25] FRENNERT, Susanne; ÖSTLUND, Britt. Seven matters of concern of social robots and older people. International Journal of Social Robotics, 2014, 6: 299-310.
[26] TANG, Sarah; KUMAR, Vijay. Autonomous flight. Annual Review of Control, Robotics, and Autonomous Systems, 2018, 1: 29-52.
[27] MARZOUK, Osama A. Urban air mobility and flying cars: Overview, examples, prospects, drawbacks, and solutions. Open Engineering, 2022, 12.1: 662-679.
[28] MOFOLASAYO, Adekunle. Potential policy issues with flying car technology. Transportation Research Procedia, 2020, 48: 8-22.
[29] AHMED, Sheikh Shahriar, et al. The flying car—challenges and strategies toward future adoption. Frontiers in Built Environment, 2020, 6: 106.
[30] CHOI, Ja-Seong, et al. A study on vertiport installation standard of drone taxis (UAM). Journal of the Korean Society for Aviation and Aeronautics, 2021, 29.1: 74-81.
[31] ALQAHTANI, Hamed; KUMAR, Gulshan. Efficient Routing Strategies for Electric and Flying Vehicles: A Comprehensive Hybrid Metaheuristic Review. IEEE Transactions on Intelligent Vehicles, 2024.

[32] HEIDENREICH, Sven; SPIETH, Patrick; PETSCHNIG, Martin. Ready, steady, green: Examining the effectiveness of external policies to enhance the adoption of eco-friendly innovations. Journal of Product Innovation Management, 2017, 34.3: 343-359.
[33] LEUTENEGGER, Stefan, et al. Flying robots. Springer Handbook of Robotics, 2016, 623-670.
[34] GRODZINSKY, Frances; WOLF, Marty J.; MILLER, Keith. Applying a Social-Relational Model to Explore the Curious Case of hitchBOT. On the Cognitive, Ethical, and Scientific Dimensions of Artificial Intelligence: Themes from IACAP 2016, 2019, 311-323.
[35] FRASER, Kathleen C., et al. How do we feel when a robot dies? Emotions expressed on Twitter before and after hitchBOT's destruction. In: Proceedings of the Tenth Workshop on Computational Approaches to Subjectivity, Sentiment and Social Media Analysis. 2019. p. 62-71.
[36] GUNKEL, David J. Robot rights. MIT Press, 2018.
[37] DAMASIO, Antonio. Descartes' error: Emotion, rationality and the human brain. New York: Putnam, 1994, 352.
[38] EPLEY, Nicholas; WAYTZ, Adam; CACIOPPO, John T. On seeing human: a three-factor theory of anthropomorphism. Psychological review, 2007, 114.4: 864.
[39] DOVIDIO, John F., et al. Prejudice, stereotyping and discrimination: Theoretical and empirical overview. Prejudice, stereotyping and discrimination, 2010, 3-28.
[40] SINGER, Peter. Animal Liberation: A New Ethics for our Treatment of Animals. Harper, 1975.
[41] BRYSON, Joanna J. Patiency is not a virtue: the design of intelligent systems and systems of ethics. Ethics and Information Technology, 2018, 20.1: 15-26.
[42] ARND-CADDIGAN, Margaret. Sherry Turkle: Alone Together: Why We Expect More from Technology and Less from Each Other: Basic Books, New York, 2011, 348 pp, ISBN 978-0465031467 (pbk). 2015.
[43] BROOKS, R. A. It's 2001 already. Flesh and machines: How robots will change us, 2002, 63-98.
[44] FRIEDMAN, Cindy. Human-robot moral relations: Human interactants as moral patients of their own agential moral actions towards robots. In: Artificial Intelligence Research: First Southern African Conference for AI Research, SACAIR 2020, Muldersdrift, South Africa, February 22-26, 2021, Proceedings 1. Springer International Publishing, 2020. p. 3-20.
[45] FREY, Carl Benedikt Frey, OSBORNE, Michael. The future of employment: How susceptible are jobs to computerisation?, Technological Forecasting and Social Change, Volume 114, 2017,Pages 254-280.
[46] Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. W W Norton & Co.

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