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Thermal Imaging in Robotics as a Privacy Enhancing or Privacy Invasive Measure? The Necessity of a Holistic Approach to Privacy in Human-Robot Interaction

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The conflicting use of thermal imaging in robotics

When robots interact with humans, how to preserve the privacy of the human users is a concern, including what the robot 'sees.' In some robotics research, the use of thermal imaging is chosen to 'conceal the individual's identity' (Valdivelu et al., 2017). The emphasis is on masking identifiable information in the images, such as details of the face, by using thermal cameras instead of regular RGB cameras (Schulz et al., 2018). The assumption is that once the clear facial image of a person is removed, the person is no longer identifiable, thus privacy is protected. Thermal imaging is for example proposed to be used in fall detection in bathrooms for elderly people and patients. Instead of a robot or a person following the person into the bathroom, the robot mounted with a thermal imaging camera can be outside the room, thereby presumedly preserving the privacy of the person not being observed during activities in the bathroom (Kido et al., 2009).

By contrast, other robotics researchers explore the possibility of using thermal imaging to improve or personalize human-robot interaction. Thermal cameras are for example used in robots to monitor physiological changes in elderly persons by detecting subtle changes in facial temperatures (Coşar et al., 2018); emotion recognition in children tracking facial landmarks during child-robot interaction (Goulart et al., 2019); and to detect emotions with the aim of strengthening the human-robot interaction (Pavladis et al., 2002). Other possible use areas for thermal imaging are to detect deceit by recording the thermal patterns from faces, i.e., as a polygraph (Pavladis et al., 2002); gender recognition (Nguyen et al., 2017); pain monitoring (Erel & Özkan, 2017); detection of sexual arousal (Liberati & Nagataki, 2019); monitoring of diseases (Brzezinski et al., 2021); or for fever detection or monitoring (Yang et al., 2020).

Hence, thermal imaging can reveal personal information which is hidden from view, such as health data and emotions. Another intrusive property of the technology is that it can detect people through barriers, unlike a regular camera. Thermal imaging is therefore magnifying the capacity to observe and enhances the robot's ability to detect and process personal data.

The misconception of privacy

In robotics research, privacy is most often understood as informational privacy or not defined at all (Lutz et al., 2019). Similarly, when robotics research on the use of thermal imaging refers to preserving or protecting privacy, privacy is understood as a person not being seen clearly. By obscuring or removing the facial image, or not seeing the body of the person, privacy is maintained. However, this simplified view of privacy fails to recognise that informational privacy is only on type of privacy (GoodBrother, 2021), in addition to bodily, spatial, communicational, proprietary, intellectual, decisional, associational, and behavioural privacy (Koops et al., 2017). These notions of privacy are particularly relevant for robots due to both their physical presence and complex data processing capacities (Fosch-Villaronga, 2019). Although legal researchers have addressed privacy in robotics, this seem to be lost in translation when crossing-over to other fields of robotics research, which leaves a gap between the technical and legal research. As Rueben et al. (2018) has proposed, privacy-sensitive robotics should be concerned with all different aspects of privacy.

Thermal cameras as privacy preserving tools are based on the notion that the robot will then not 'see'. But does the robot 'see'? The robot itself will not be interested in the images of people. Whether it needs images or not to function, is dependent on its purpose. This also extends to the use of thermal imaging. If the robot needs to 'see' to be able to not only detect, but to identify a person, it will need the data feed from the RGB cameras, e.g., the robot needs to ascertain that it is administering medicine to the right person. A robot may also need to use several sensors, including thermal imaging, to be able to detect, identify and interact properly and safely with that person. Using anthropomorphic language to describe the robot's features thus obscures the actual features and complexities of the technology (Grimm, 2021).

The anthropomorphic design of robots raises concerns that the design may give users a false sense of comfort (Rueben & Smart, 2016). A robot closing its 'eyes' or turning its back to the user may make the user more comfortable and at first glance may seem privacy friendly (Yang et al., 2022). However, thermal cameras and other sensors may be placed elsewhere on the robot and not designed as eyes (Kaminski et al., 2017). Thus, these techniques may reassure the user, while at the same time be deceiving as to the full scope of what the robot is 'sensing'. Kamenski et al. (2017) have suggested a principle of 'honest anthropomorphism' to avoid deliberately misleading users as to what the robot is doing. On the same note Schafer & Edwards (2017), propose that robots should be built with their sensory capacity openly displayed. How, and if, this would be manifested in robotics design is another matter.

The use of thermal imaging as a replacement to RGB cameras is often based on an understanding that this will not be personal data (Hassan & Bessam, 2019; Tørresen, 2021), thus not acknowledging the intrusive nature of thermal imaging and the consequences for privacy. The different definitions of personal data across jurisdictions as well as the complexity and variety of the scope of privacy, may contribute to this confusion. As argued by Purtova (2018), the distinction between personal and non-personal data may no longer be meaningful with the increase of datafication and advances in data analytics and smart environments. This is particularly relevant for human-robot interaction where most, if not all, of the data can be related to an identifiable individual, whether the data is observations of the person or more technical data of the robot's performance. Applying a broad concept of personal data in robotics would ensure that data is treated as personal data, and reduce the risk of misconceptions such as treating data inferred from thermal imaging as non-personal data. Although this is an EU centric approach to personal data, the global nature of development of robotics would benefit from the most extensive definition being used instead of the lowest common denominator.

It is encouraging that privacy by design and data minimisation are addressed in robotics, but as the example of thermal imaging shows, replacing one sensor for another may not be privacy preserving but instead increases the invasiveness of the technology. Scherer's (2016) observations that the interaction between a variety of software and hardware components developed separately in various geographical locations increases the complexity of managing risks in AI, is even more pertinent for robotics. Instead of assessing each sensor in isolation, robot design must be considered in relation to its purpose and functionality. Hence, we need to ascertain a holistic approach to privacy in human-robot interaction. This will require cross-disciplinary work, where one of the contributions of legal scholars would be to draw on the extensive privacy scholarship, as proposed by Rueben et al. (2018), and to clarify the notion of personal data in robotics, and how data can be minimised without compromising safety and security or even by increasing privacy risks.

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