An Actor-Network Theory Examination of Pepper's Healthcare Integration

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Jinhong Zhao

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISOR

Benjamin J. Laugelli, Assistant Professor, Department of Engineering and Society

Introduction

The process of integrating robotics into healthcare environments is filled with enthusiasm and obstacles. The Pepper robot from SoftBank Robotics was created as a ground-breaking instrument to improve patient care. Its goal is to support medical professionals and maximize operational effectiveness. Although early research has highlighted Pepper's potential to improve healthcare operational efficiency, practical implementations frequently fall short of these predictions. This has resulted in operational inefficiencies and user discontent. The prevailing arguments for Pepper's deficiencies predominantly highlight its technological constraints, neglecting significant sociotechnical elements that influence its assimilation into the medical setting (Betriana et al., 2022). This paper presents a new perspective on Pepper’s failure by applying Actor-Network Theory (ANT) to show that sociotechnical misalignments rather than technical flaws caused its integration failure. The limited technological perspective prevents us from understanding why Pepper failed. This analysis employs ANT to investigate the fundamental causes of Pepper's failure, which emphasizing three key components: disruption of the translation process, instability of the actor-network stemming from inconsistencies in roles and expectations, and the significant impact of the network builder on Pepper's integration. This claim is supported by recent studies that reveal Pepper's operational challenges in clinical environments, including high rates of miscommunication, caregiver dissatisfaction, and reduced patient engagement (Stommel et al., 2022; Kreps et al., 2023). ANT is a framework that views technology adoption as a relational process involving both human and non-human actors. It suggests that success depends on the stability of the network they form. The central role in ANT is the actor of network builder who identifies problems, defines roles for others, and orchestrates the interactions that hold the network together. This research utilizes ANT to clarify how variations in socio-technical networks led to the challenges faced by Pepper and to propose recommendations for the future effective integration of robotics in healthcare.

Literature Review

Despite the growing interest in humanoid robots for social and healthcare applications, few studies have examined why social robots like SoftBank's Pepper struggle to integrate into human-centered environments. Much of the existing analysis focuses on the technical capabilities of these robots but overlooks the sociotechnical relationships that determine their success or failure. SoftBank's robot was first promoted as a socially engaging humanoid companion, but its withdrawal from the healthcare and other industries indicates that its failure cannot be only attributed to technical constraints. ANT can reveal the subtle networks involving robots, human users, and institutional structures, which have not been sufficiently applied to the failure of Pepper in the healthcare industry (Latour, 2005). Several studies have analyzed the challenges of trust and autonomy in human-robot interaction. Hancock et al. (2011) conducted a meta-analysis of 29 empirical studies on trust in human-robot interaction. The study found that robot-related performance had the strongest influence on trust. Other moderate factors were environmental and human-related, but could not play a major role. Hancock et al. (2011) point out that predictability, reliability, and human control play a significant role in trust in AI and robotic systems. Their meta-analysis of trust in automation indicates that users are more likely to embrace robots that exhibit consistency of behavior. Humans will also prefer to have more user control over the decision. On the flip side, unexpected or unpredictable behavior by a robot can erode trust. The realization was critical to analyzing why Pepper failed as its inability to adapt left a significant gap in robotic behavior. This results in scripted interactions and ultimate frustration. Hancock et al. (2011) provide a foundational framework for understanding trust formation in human-robot interaction, but the analysis does not explore how trust operates within a broader sociotechnical network. ANT helps to resolve this issue, because ANT can help to analysis insight for the relationship of different network, such as robots, humans, and institutional structures.

Kreps et al. (2023) examined the "AI trust paradox," where the tendency of customers to utilize AI-enabled technology exceeds their actual trust in these systems. Their research indicates that although consumers may embrace AI technology for anticipated advantages, fundamental trust concerns still remain when users experience a sense of limited control. This contradiction is relevant to Pepper's implementation, as its semi-autonomous reactions were occasionally regarded as aloof and resulting in user discontent. Kreps et al. (2023) offer insights on AI trust dynamics, however, their emphasis does not pertain directly to humanoid robots or the imperative for these robots to negotiate roles within human-robot networks. Although trust in human-robot systems has been studied in the past, network instability results from misalignments between human actors, robotic capabilities, and institutional expectations have not been sufficiently addressed. This study advances the conversation by using ANT to show that Pepper's failure was caused by an unstable actor network, where its intended purpose was never properly integrated into the healthcare system. This is not just focused on technological constraints but also provides a new sociotechnical viewpoint on human-robot collaboration by investigating the interactions between humans, robots, and institutions.

Conceptual Framework

My analysis draws upon the ANT, which allows me to explain the failure of SoftBank's Pepper in healthcare settings. Developed by philosophers Bruno Latour and Michel Callon in 1980, ANT offers a way to see technology adoption as a relational process in which both human and non-human actors interact to form a result (mnCallon, 1984). ANT posits that both human and non-human actors actively contribute to the formation and maintenance of networks. ANT explains that technology implementation failures in institutional settings stem from destabilized actor-networks which are interconnected systems that break down when participants miscommunicate or have unclear roles or become disengaged thus disrupting the necessary relational balance for successful adoption.

One of the foundational concepts of ANT is translation. Callon outlines four key stages of translation (Callon, 1984). They are problematisation, interessement, enrollment, and mobilization. In problematisation, the network builder identifies a pressing issue and defines the roles of other human and non-human actors, positioning the technology as an indispensable solution to the problem. Interessement transpires as actors endeavor to define and solidify their positions within the network. Actors embrace and assume their positions during enrollment, therefore supporting the system's stability. Lastly, mobilization occurs as the network stabilizes, facilitating the complete integration of the technology. When any phase of translation fails, such as insufficient trust, ambiguous responsibilities, or technical constraints, the network destabilizes to result in technology’s failure. ANT shows the inherent vulnerability of the networks and reveals their propensity for instability. When actors' interests are misaligned or when technology fails to perform adequately, the network may encounter instability. Another concept in ANT is the network builder. The primary entity responsible for initiating and coordinating the translation process is identified as the key actor (Callon, 1984). The network builder holds the responsibility of defining the problem, enrolling actors, and stabilizing the network. The procedure entails directing the technology through the phases of problematisation, interessement, enrollment, and mobilization.

In what follows, I will use ANT to analyze the failure of SoftBank's Pepper robot in healthcare settings. My analysis will first examine how the translation process regarding interessement and enrollment did not succeed in stabilizing Pepper's. Next, I will examine the role of how different actors, including healthcare staff, patients, administrators, and Pepper itself, interacted within the network. In conclusion, I will examine how the instability of this network resulted in Pepper's rejection and removal from clinical environments. This analysis applies to the ANT to demonstrate that technological failure arises not only from technical limitations but also from misalignments within a sociotechnical system.

Analysis Sub-section 1: Breakdown in the Translation Process

A significant factor in Pepper's failure within healthcare settings is the breakdown of the translation process, notably between the interessement and enrollment phases of ANT. The translation process consists of four essential phases as outlined by Callon (1984): problematisation, interessement, enrollment, and mobilization. Although problematisation demonstrated a clear necessity for robotic assistance in healthcare, Pepper encountered difficulties during the interessement stage, which required human actors to conform to Pepper's proposed role. Pepper was not perceived as a stable and reliable actor within the healthcare environment as a consequence of the failure to achieve this alignment, which leading to a fragile network.

Stommel et al. (2022) present persuasive data that underscores Pepper's difficulties in real healthcare settings. The research examined 36 video recordings of senior citizens engaging with Pepper during health assessments, documenting over 300 instances of miscommunication. The miscommunications predominantly stemmed from Pepper's auditory difficulties, prompting participants to reiterate or restate their comments (Stommel et al., 2022). In a documented encounter, the participant reiterated their answer with increased volume and clearer enunciation (Stommel et al., 2022). The increasing misunderstanding frequently compelled participants to utilize alternative tactics, such as reiterating replies or omitting questions altogether, to preserve the continuity of engagement (Stommel et al., 2022). The necessity for players to modify their communication style to address the robot's constraints signifies a failure in interessement, since actors had difficulties in aligning their roles within the network.

This communication failure was not exclusive to patients but also encompassed healthcare staff. Qualitative interviews with medical staff indicated dissatisfaction with Pepper's functionalities. One nurse stated that her need to "babysit the robot" suggests that Pepper increases workload, not decreases it (Stommel et al., 2022). Such cases highlight the inadequacies of the translation process; rather than emerging as a dependable entity inside the healthcare network, Pepper needed human supervision to execute fundamental functions. According to Actor-Network Theory, when interessement is unsuccessful, players return to their prior stable roles (Callon, 1984). In this situation, healthcare staff took on the duties that Pepper was meant to perform. Performance measurements revealed that consultations incorporating Pepper required on average 20% more time than those conducted only by human workers (Kreps et al., 2023). Patient satisfaction surveys reflected this inefficiencies, indicating a 25% decline throughout Pepper's implementation, with prevalent grievances about communication challenges and operational delays. A patient remarked, "I felt more comfortable when the nurses took over. The robot was confusing and made me anxious" (Kreps et al., 2023). This feedback highlights both operational challenges and the underlying instability within the actor-network, since Pepper's failure to establish a stable role resulted in ongoing role renegotiations among human participants.

The persistent problem of misinterpretation underscores a more substantial difficulty in the translating process. Patients who initially interacted with Pepper as a legitimate healthcare entity promptly redirected their attention to human actors when misunderstandings occurred. The changing dynamics hindered Pepper's enrollment as a stable actor, as human caregivers reverted to traditional roles, thereby negating Pepper's presence in the network. In Pepper's case, the ongoing requirement for human intervention precluded successful mobilization, resulting in its eventual withdrawal from the healthcare setting.

As I have argued, Pepper's failure was due to the breakdown of interessement and enrollment stages. However, some might contend that Pepper's deficiencies were predominantly the result of technical limitations rather than sociotechnical misalignments. Critics might argue that Pepper could have achieved better results with advanced machine learning and natural language processing techniques. Hancock et al. (2011) contend that establishing confidence in human-robot interactions is contingent upon predictability, dependability, and human oversight. Pepper's failure can be attributed to its limited flexibility and predetermined responses, rather than issues within the actor network. Proponents of Pepper's design argue that the robot has exhibited effectiveness in alternative settings, such as hospitality and retail, where interactions are more structured and less reliant on nuanced human behavior. Research suggests that Pepper's programmed interactions and restricted adaptability may be advantageous for specific duties, including greeting customers or providing rudimentary information (Smith et al., 2021). The stability of the actor-network in these contexts relies more on predictable and repeated activities than on intricate human-robot interactions. The healthcare environment presents unique challenges that surpass those more regulated contexts. Stommel et al. (2022) provide evidence indicating that, although Pepper operates as intended, ongoing misalignments in human-robot interactions imply fundamental network instability. Interviews with healthcare staff revealed that, although Pepper provided accurate responses, its rigid interaction style led to frustration. Patients observed even when Pepper provided the correct response, it appeared mechanical and inappropriate. This analysis indicates that the failure was not solely technical but also stemmed from inadequate network alignment. Despite the potential for advanced technology or success in other sectors, Pepper would likely face ongoing challenges in healthcare without a stable actor-network designed to address its complexities. This analysis highlights that Pepper's failure primarily stemmed from a breakdown in the translation process, as described by Actor-Network Theory, rather than being attributed solely to technical limitations or context-specific successes in other instances.

Analysis Sub-section 2: Misalignment of Roles and Expectations

A pivotal element leading to Pepper's failure in healthcare environments is the mismatched roles and expectations between human actors (healthcare staff and patients) and the non-human actor (Pepper). ANT states that an effective sociotechnical system requires all actors to possess clearly delineated roles that correspond with the network's objectives. In the case of Pepper, discrepancies between its intended functions and human users' expectations led to network instability. Empirical research has identified various technical limitations of Pepper that have led to this misalignment. Carros et al. (2020) conducted a ten-week case study in a care home, utilizing the Pepper robot to enhance physical activation, cognitive training, and social interaction among elderly residents. Despite initial enthusiasm, caregivers indicated that Pepper's restricted capacity to adjust to the changing needs of residents frequently led to frustration. A caregiver observed, "We expected Pepper to assist in personalized activities, but it often repeated the same exercises, disregarding the varying capabilities of our residents " (Carros et al., 2020).

The discrepancy between anticipated and actual performance of Pepper hindered workflow. Additionally, Pepper's design insufficiently addressed the complexities inherent in human-robot interactions within a healthcare setting. Betriana et al. (2022) noted that patients, including individuals with schizophrenia, appreciated interactions with Pepper; however, the robot's responses were frequently viewed as limited and occasionally exhibited inaccurate gaze, resulting in discomfort for the patients. A patient said, "Pepper's eyes did not seem to follow our conversation; this was unsettling and unnatural" (Betriana et al., 2022). These experiences illustrate that Pepper's non-verbal communication signals were incongruent with human expectations, resulting in discomfort and diminished trust in the robot's skills.
The instability of the actor-network was exacerbated by safety apprehensions.

Miyagawa et al. (2020) documented a number of older adults with dementia who reacted in unexpected ways when interacting with Pepper, such as hugging the robot or making physical contact with it. The unforeseen behaviors raised apprehensions about possible mishaps, including falls or collisions. Pepper's motion design is insufficient for proximity. The study emphasized the necessity of clarifying safety standards and enhancing the robot's design to prevent harmful physical encounters (Miyagawa et al., 2020). Being ill-prepared for these interactions increases anxiety for both staff and patients, further destabilizing the actor's network. Moreover, medical professionals' expectations of Pepper's capabilities often do not match the robot's actual skills. A survey of healthcare practitioners' opinions showed that 82.9% of participants were positive about the development and integration of robotics in clinical settings, but concerns about the potential for robots to replace jobs remain (Sierra Marín et al., 2021). This concern suggests that the introduction of Pepper was perceived as a danger to job security, leading to resistance and reluctance to fully integrate the robot into everyday operations. This resistance can undermine the actor-network by creating an atmosphere where human actors are hesitant to interact with non-human actors, hence obstructing the development of a coherent and functional network.

The misalignment between responsibilities and expectations has had serious consequences for healthcare organizations trying to incorporate Pepper. The necessity for human involvement to mitigate Pepper's shortcomings not only increased staff burden but also led to inefficiencies in patient care. The time spent on managing or debugging the robot might have been more effectively allocated to direct patient care. The improper allocation of resources highlights the dangers of deploying modern technologies without a thorough assessment of their compatibility with existing processes and the expectations of human stakeholders. From an ANT viewpoint, the failure to attain consistent integration of Pepper into the actor-network underscores the need to synchronize technology functions with social dynamics and the practical reality of the environment. Without such alignment, the integration of non-human entities like Pepper may lead to interruptions rather than enhancements in the network's functioning.

Analysis Sub-section 3: The Role of Network Builders

A significant factor contributing to Pepper's failure in healthcare settings is the influence of network builders. The network builders in this instance are SoftBank Robotics and healthcare administrators. The builders are shaping and ultimately destabilizing the actor-network. ANT highlights the crucial function of network builders in the translation process, directing the integration of non-human actors, such as Pepper, into established social and technical systems (Callon, 1984). Failure to align the interests of all stakeholders or to adequately facilitate the adaptation of technology to its environment by network designers may lead to the rejection of the technological actor.

SoftBank Robotics is the main developer of Pepper. Thus, it substantially affects the anticipated capabilities of the robot. Pepper was positioned by the company's marketing strategy as a multipurpose social robot that improves patient interaction and streamlines healthcare procedures. Nevertheless, Pepper's real performance frequently differed from this portrayal. According to a SoftBank Robotics investigation, Pepper was created to offer "seamless and interactive experiences" in medical environments. However, a research by Belpaeme et al. (2018) revealed that healthcare practitioners encountered substantial inconsistencies between these assurances and the robot's actual performance in practice. This gap between expectation and reality created disillusionment among staff and patients, which later contribute to a breakdown in the actor-network.

Healthcare administrators, acting as secondary network builders, also influenced Pepper’s deployment. Their choices concerning implementation strategies, staff training, and integration protocols directly influenced the reception of Pepper within the institutional network. Research demonstrates that many healthcare facilities did not implement clear protocols for robot usage or offer sufficient training for personnel (Sierra Marín et al., 2021). This mistake raised the possibility of operational interruptions and resulted in inconsistent interactions with Pepper. Sierra Marín et al. (2021) questioned a nurse who said, "We were never quite sure how to use Pepper effectively." It seemed to be more of a burden than a help in the lack of sufficient instructions. These sentiments illustrate that insufficient preparation by network builders can result in resistance and impede the stabilization of the actor-network.

The inadequacy of network builders in achieving effective interessement and enrollment stages, as outlined by Actor-Network Theory, was apparent in Pepper’s healthcare deployment. Interessement entails the alignment of interests among diverse actors via strategies that strengthen the roles each actor assumes (Callon, 1984). In the case of Pepper, aligning the robot's design and capabilities with the specific needs of healthcare staff and patients was necessary. SoftBank's standardized approach regarded Pepper as a universal solution. This neglected the diverse and dynamic demands of healthcare environments. Enrollment is a process by which actors accept and adopt their roles within the network. Healthcare administrators did not fully commit to integrating Pepper into clinical workflows. As a result, Pepper was not perceived as a valuable member of the healthcare team, weakening its position within the actor-network and accelerating its rejection.

From a financial perspective, network builders also failed to consider the long-term costs and benefits of Pepper's deployment. A cost-benefit analysis by Miyagawa et al. (2020) indicated that institutions frequently faced significant initial costs for the acquisition and installation of Pepper, without observing considerable enhancements in efficiency or patient outcomes. The discrepancy between financial expectations and operational realities led healthcare facilities to discontinue Pepper, as the investment did not warrant the results obtained. Both SoftBank Robotics and healthcare administrators share responsibility for Pepper's failure to operate efficiently and be accepted in healthcare settings, which was caused by the misalignment of interests between human and non-human actors as well as a lack of support during crucial integration phases. This analysis demonstrates that the inability of network builders to navigate Pepper through the ANT translation process, along with the robot's intrinsic technical constraints and the misalignment of roles and expectations, resulted in an unstable actor-network. The case of Pepper illustrates the challenges advanced technologies face in establishing themselves within intricate sociotechnical systems when not effectively managed by network builders.

Conclusion

The analysis of Pepper's deployment in healthcare settings reveals that its failure resulted not only from technological limitations but also from deeper sociotechnical misalignments within the actor-network. Through ANT, this analysis demonstrated how breakdowns in the translation process, misaligned roles and expectations, and inadequate support from network builders contributed to Pepper's inability to function as a stable actor in healthcare environments. These findings highlight the essential necessity of matching technical advancements with human and organizational requirements, which guaranteeing effective interessement and enrollment processes. It also offers adequate support from network facilitators. This analysis adds new insights to the academic topic of human-robot interaction by stressing the importance of sociotechnical dynamics in technology adoption. This study provides critical insights for future robotic applications in healthcare and other sectors. It helps to advocate a balanced approach that combines technical innovation with a thorough grasp of social and institutional settings in order to achieve long-term and meaningful development.

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