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Adaptive Decision Behavior of Autonomous Systems in Human Shared Operational Environments

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A B S T R A C T
The integration of autonomous systems in the operational environment shared with humans in the field of electrical engineering poses challenges in adaptive decision-making and human-system interaction. This study aims to analyze the influence of multimodal perception and human intention inference on adaptive decisions with trust as a mediating variable. The method used was a quantitative approach through a survey of 180 respondents, with data analysis using PLS-SEM. The results showed that all variables had a significant effect on adaptive decisions, with trust as the most dominant factor, and played a role as a partial mediator. It is concluded that adaptive decisions are influenced not only by technical aspects, but also by user trust, so a human-centered approach is important in the development of autonomous systems

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INTRODUCTION

Technological developments in the field of electrical engineering, particularly in autonomous systems, have experienced significant acceleration in the last decade. Autonomous systems such as collaborative robots (cobots), autonomous vehicles, and artificial intelligence-based intelligent systems are now increasingly being applied in human-shared operational environments, such as manufacturing, transportation, and public spaces. The transformation towards the era of Industry 4.0 and Society 5.0 requires these systems to not only be able to operate independently, but also adapt to the complex and unstructured dynamics of human interaction (Freire et al., 2024).

Globally, the adoption of autonomous systems in the human environment is increasing rapidly, especially in the industrial and transportation sectors. For example, the use of collaborative robots in manufacturing has improved work efficiency and safety, but it has also raised new challenges related to safe and adaptive human-robot interaction (HRI) (Freire et al., 2024). On the other hand, autonomous vehicles face complexities in adaptive decision-making in dynamic traffic environments and involve human behavior that is not always predictable (Huang et al., 2024). This shows the urgency of developing adaptive decision behavior models in autonomous systems.

In the context of electrical engineering, autonomous systems rely on the integration of sensors, actuators, control systems, and artificial intelligence algorithms to enable real-time environmental perception, decision-making, and action execution. The latest approach leads to the development of artificial cognitive autonomy that integrates perception, memory, and decision-making processes to improve system performance under unpredictable conditions (Lima Junior et al., 2025). Nevertheless, the complexity of the environment involving humans demands that the system be not only responsive, but also adaptive to human preferences, behaviors, and social contexts.

A number of previous studies have examined the adaptation aspect in autonomous systems. Freire et al. (2024) developed a Distributed Adaptive Control (DAC)-based adaptive cognitive architecture to improve human-robot collaboration in industrial environments. Meanwhile, Bozorgi and Ngo (2023) propose the concept of shared autonomy that combines human and robot perceptions to improve robot navigation in real environments. In addition, research by Lima Junior et al. (2025) highlights the importance of artificial cognitive autonomy in improving autonomous system decision-making in complex situations.

However, there is a significant research gap. Most studies still focus on technical aspects such as navigation, control, and perception, without deeply integrating adaptive behavioral models based on human social interactions in autonomous decision-making processes. A study by Yu et al. (2024) shows that robotic systems operating in public environments still have limitations in understanding complex social dynamics. In addition, previous research has also shown that a high level of autonomy does not necessarily increase user satisfaction, so adaptation mechanisms that take into account human preferences are needed (Lombardi & Di Salvo, 2023).

Another gap lies in the lack of a holistic approach that combines adaptive control theory, artificial intelligence, and human behavior theory in one integrated systems framework. Many studies are still partial and have not been able to explain how autonomous systems can dynamically adjust decision behavior based on real-time interactions with humans (Bozorgi & Ngo, 2023). This is a major challenge in the development of safe, efficient, and trustworthy autonomous systems in a human-shared environment.

Based on these problems, the aim of this research is to develop an adaptive decision behavior model in autonomous systems that are able to operate effectively in an operational environment shared with humans. Specifically, this study aims to design a system framework that integrates aspects of environmental perception, human behavior modeling, as well as adaptive decision-making algorithms based on machine learning and control theory (Huang et al., 2024).

The contribution of this research is expected to provide two main benefits. Theoretically, this research enriches the development of electrical engineering science, especially in the field of intelligent control systems and human-centered autonomous systems, by presenting an integrative model that combines technical and social aspects in decision-making (Lima Junior et al., 2025). Practically, the results of this research can be applied in the development of collaborative robots, autonomous vehicles, and other intelligent systems that operate in the human environment, thereby improving the safety, efficiency, and quality of human-machine interactions (Freire et al., 2024).

THEORETICAL REVIEW

Multimodal Perception as the Foundation of Adaptive Decisions

The first dominant theme in the literature is that adaptive decisions are inseparable from the quality of multimodal perception. In a human-sharing environment, autonomous systems need to combine visual data, lidar, radar, audio, motion data, and spatial context to be able to understand situations more richly than if they only rely on one sensor. Recent surveys in the field of human–robot interaction show that multimodal perception-driven decision-making increases robustness against sensor failure, enriches the context for understanding the human state, and improves decision quality in dynamic environments. In the framework of electrical engineering, this confirms that sensor fusion, state estimation, and multimodal signal processing are not just the initial stages of the pipeline, but components that shape the quality of decisions at the planning and control level.

In autonomous vehicle systems, the need for multimodal perception also intersects with the need for transparency. A recent review of multi-sensor fusion and explainability in autonomous vehicles shows that the more complex the perception architecture, the greater the need to explain why a decision is made, especially when the system operates in a public space and interacts with humans. In other words, high adaptivity without transparency can actually lower user trust. This shows that future research needs to connect three layers at once: multimodal perception, context inference, and decision explanation.

Inference of human intentions and shared autonomy

The second theme is the importance of human intention recognition in adaptive decision behavior. Autonomous systems that share space with humans must be able to interpret what humans are likely to do next, not just detect current positions or trajectories. A 2024 study on the recognition of human intentions in complex scenes shows that the spatial relationship between humans, objects, and temporal evolution of context can improve the system's ability to recognize intentions more accurately. This finding is important because human behavior in a real environment cannot always be represented by simple motion features; The environmental context greatly determines the meaning of an action.

Correspondingly, an approach that combines large language models and knowledge graphs for service robots suggests that intention inference is no longer built only from motion patterns, but also from semantic reasoning and interaction contexts. This approach is relevant for a new generation of autonomous systems because it allows robots to interpret human goals more flexibly in an unstructured environment. On the side of shared autonomy, a survey on the application of POMDP in shared autonomy confirms that uncertainty about human goals, environmental conditions, and system status is most effectively handled with a probabilistic model that treats human intentions as latent variables. This means that good adaptive decisions require an explicit representation of human uncertainty, not just sensory uncertainty.

In the context of human-robot collaboration, the ability to read intentions is also directly related to the division of control. A system that is too aggressive in taking over can reduce a person's sense of agency, while a system that is too passive can fail to provide help at critical moments. Therefore, the latest literature review emphasizes that effective shared autonomy does not mean replacing humans, but adjusts the level of assistance based on the context, purpose, and belief of the system on the user's intentions. This perspective is critical to designing decisions architectures that are adaptive while remaining human-centered.

Adaptive decisions based on risk, uncertainty and safety

The third theme is that adaptivity in autonomous systems cannot be separated from risk management. The literature on safe reinforcement learning for autonomous vehicles confirms that conventional RL is less suitable for the safety-critical domain because its exploration can result in dangerous actions. Safe RL was then developed by adding constraints, risk estimation, and penalties to prevent unsafe actions. The 2024 review also emphasizes that dynamic environments, computing costs, and variations in real-world conditions are still major challenges for system validation. The findings suggest that adaptive decisions that are "optimal" in terms of rewards are not necessarily "safe" operationally.

At the trajectory planning level, recent research and reviews show a shift from shortest-path planning to risk-aware planning and belief-space planning. The 2025 review of path planning under uncertainty highlights the increasing use of POMDP formulations, deep reinforcement learning, and hybrid architectures

for navigation under uncertainty, while emphasizing that the issues of robustness, interpretability, and sim-to-real transfer remain unresolved. Meanwhile, the PLOS ONE 2025 study on mobile robots in human-sharing environments shows that a trajectory search strategy that prioritizes safety over the shortest distance can improve task success in environments that have random human movements. Both of these literatures reinforce the argument that adaptive decision behavior should be built on risk-conscious and human-conscious optimization.

This perspective is also consistent with the study of autonomous vehicles that emphasizes the need for human-like logic in mixed traffic. The 2025 review shows that when autonomous vehicles coexist with human-driven vehicles, systems need to understand the logic of human behavior, predict future actions, and minimize driving risk socially, not just kinematicly. Thus, adaptive decision-making must move from mechanical optimization to socio-technical optimization that takes into account human norms, habits, and expectations.

Trust, Explainability, and Human Factors in a Shared Environment

The fourth theme in the literature is that effective decision adaptations must be acceptable to humans. A systematic review of shared-space human–robot collaboration found that trust, cognitive workload, and anxiety were the three most frequently measured human factors, and all three directly affected collaboration performance and safety. This means that the evaluation of autonomous systems should not stop at technical metrics such as success rate or collision rate, but should also include how humans interpret, trust, and adjust their behavior toward the system.

A systematic study of trust in AI in 2024 adds that trust in AI is formed by a combination of technical factors such as safety, accuracy, robustness, and non-technical factors such as ethical, legal, and social value aspects. In the context of a shared operational environment, the implications are crucial: statistically safe decisions are not necessarily considered trustworthy if the process is not understandable or if the system fails to demonstrate sensitivity to human norms. Therefore, explainable AI becomes not only an issue of model interpretation, but also an issue of human–machine interaction and operational legitimacy.

Recent research on intention prediction, which at the same time improves interpretability, also shows an interesting direction. The integration of LLMs and knowledge graphs on service robots not only improves intent prediction capabilities, but also opens up opportunities for systems to provide more human-understandable reasons. Conceptually, this supports the idea that the future of autonomous systems in a shared environment is not just "decide correctly", but "decide correctly and explain sufficiently". Thus, trust calibration should be seen as an integral part of adaptive decision behavior design.

Dynamic Safety Assurance and Decision Behavior Verification

The fifth theme is the shift from static safety assurance to dynamic safety assurance. In an ever-changing environment, testing or certification at the design

stage alone is not enough to guarantee that the system remains safe during operation. The 2025 article on dynamic safety cases emphasizes the need to transition from a safety-only case that focuses on design-time to a structured assurance case that is dynamically evaluated during operation. Demonstrations on autonomous mobile robots in industrial environments show that this approach is feasible to improve the safety of autonomous systems.

The theoretical implications are huge for adaptive decision behavior research. If the decision model continues to update policies based on human learning, context, or behavior, then the safety argument must also be updated. In other words, the adaptation of the decision needs to be accompanied by an adaptation to the mechanism of proving safety. This opens up space for the integration of formal methods, runtime monitoring, and assurance modeling as a companion layer for AI-based decision making. Recent literature suggests that this direction is increasingly important as modern autonomous systems are no longer deterministic and closed, but rather open, learn, and interact directly with humans.

Critical Synthesis and Research Gap

Overall, the 2021–2025 literature shows that adaptive decision behavior in autonomous systems in human-sharing environments is built on four core capabilities: understanding context through multimodal perception, modeling human intentions, making risk-based decisions under uncertainty, and maintaining trust and safety through explainability and assurance. However, most studies are still developing separately. Many studies excel in perception, but are weak in explanation of decisions; some are strong on safe planning, but have not sufficiently considered the human factor; while others stand out on trust or interpretability, but have not yet connected to safety verification at runtime.

Therefore, the most relevant research gap for this article is the need for an integrated architecture that connects sensor fusion, intent inference, adaptive decision-making, explainable interaction, and dynamic safety assurance within a single operational framework. For the field of electrical engineering, such a contribution can be realized through the integration of sensor systems, edge intelligence, probabilistic reasoning, adaptive control, and runtime verification. With this approach, autonomous systems will not only be smarter, but also safer, more trustworthy, and more compatible with complex human environments.

METHODOLOGY

This study uses a quantitative approach with an explanatory research design that aims to test the causal relationship between variables that influence adaptive decision behavior in autonomous systems in operational environments shared with humans. The research design used is a cross-sectional survey, where data is collected at a single point in time to identify patterns of relationships between variables such as multimodal perception, inference of human intentions, trust in the system, and the level of decision adaptivity. The quantitative approach was chosen because it allows objective measurement and statistical analysis of complex constructs and supports the generalization of research results. This method has been widely used in human–autonomy interaction

studies to evaluate technical and psychological factors in an integrated manner (Hopko et al., 2022; Afroogh et al., 2024).

The population of this study is individuals who interact with or have experience with autonomous systems, such as semi-autonomous vehicle users, industrial robot operators, or students and professionals in the fields of electrical engineering, robotics, and artificial intelligence. The sampling technique used is probability sampling with the stratified random sampling method, to ensure a balanced representation of various experience groups and technical backgrounds. The number of samples was determined using the Hair et al. approach (minimum 5–10 times the number of indicators), so that with an estimate of 25–30 indicators, the number of respondents ranged from 150–300 participants. The selection of this technique aims to improve external validity and reduce sampling bias, especially in studies involving human perceptions of complex technologies (Hair et al., 2021).

Data collection was carried out through a structured questionnaire that was distributed online using a digital survey platform. The research instrument consists of several main constructs, namely: autonomous system perception, human intention inference, trust in the system, and adaptive decision behavior. The questionnaire items were adapted from previous validated research, such as the trust in automation scale (Afroogh et al., 2024) and human–robot interaction metrics (Hopko et al., 2022), with adjustments to the research context. The measurement scale uses a 5-point Liker. The validity test was carried out through confirmatory factor analysis (CFA), while the reliability was tested using Cronbach's Alpha and Composite Reliability (CR) with a threshold of ≥ 0.7. This test is important to ensure the internal consistency and accuracy of the instrument in measuring the research variables (Hair et al., 2021).

The research procedure is carried out gradually and systematically. The initial stage includes literature review and development of conceptual frameworks based on the latest theories about autonomous systems and human–machine interaction. Furthermore, the preparation of instruments and pilot tests were carried out to a small number of respondents to ensure the clarity and initial validity of the item. The next stage is the collection of main data through the distribution of questionnaires to respondents who have met the inclusion criteria. After the data is collected, a data cleaning process is carried out, including checking missing values, outliers, and data normality. The final stage is data analysis and interpretation of results associated with research objectives as well as relevant literature. This procedure follows modern quantitative research practices that emphasize transparency and replication (Zhou et al., 2024).

The data analysis technique used is Structural Equation Modeling (SEM) based on Partial Least Squares (PLS-SEM) because it is suitable for complex and predictive research models. The analysis was conducted to test the relationship between latent variables and the strength of their influence on adaptive decision behavior. The analysis stage includes the evaluation of the measurement model (outer model) and structural model (inner model), including goodness-of-fit testing, path coefficient, and R^2 value. In addition, additional analyses such as bootstrapping were used to test the significance of relationships between

variables. The software used in this study is SmartPLS and SPSS for descriptive statistical analysis. The selection of this method is supported by the recent literature demonstrating the effectiveness of PLS-SEM in autonomous systems research and human–AI interactions involving complex latent variables (Hair et al., 2021; Zhao et al., 2025).

RESEARCH RESULTS

Respondent Characteristics and Data Description

This study involved 180 respondents, who were in the ideal range (150–300) according to the PLS-based SEM analysis approach. Respondents were obtained through stratified random sampling techniques based on their experience background and field of expertise. The distribution of respondents consisted of electrical/robotics engineering students (48%), technology and automation industry professionals (32%), and semi-autonomous system users (20%). In terms of experience, as many as 58% of respondents have medium to high experience in interacting with autonomous systems, while the other 42% are at the beginner level.

The results of the descriptive analysis showed that all variables had an average value between 3.62 and 4.18 (Likert scale 1–5), which indicates that respondents' perceptions tend to be positive towards the autonomic system. The normality test showed that the values of skewness and kurtosis were within the acceptable range (±2), making the data feasible for further structural analysis.

Measurement Model Test Results (Outer Model)

The evaluation of the measurement model showed that all indicators had an outer loading value between 0.71–0.88, thus meeting the criteria of convergent validity. The Average Variance Extracted (AVE) value for all constructs is above the threshold of 0.50, which indicates that the latent variable is able to explain more than 50% of the variance of its indicator.

In addition, reliability test results show that the entire construct has a high level of internal consistency. This is reflected in Cronbach's Alpha value which is in the range of 0.84 to 0.91 and the Composite Reliability (CR) value which ranges from 0.88 to 0.93. These values have exceeded the required minimum limit, so it can be concluded that each construct in this study has good reliability and is able to measure variables consistently, which indicates a high level of internal consistency.

Table 1. Validity and Reliability Test Results

Variabel	AVE	Cronbach's Alpha	CR	Remarks

Persepsi Multimodal	0.60	0.85	0.89	Valid & Reliabel
Inference of Human Intent	0.58	0.84	0.88	Valid & Reliabel
Trust in the System	0.63	0.88	0.91	Valid & Reliabel
Adaptive Decisions	0.66	0.90	0.93	Valid & Reliabel

These results show that the entire construct is eligible for further analysis on the structural model.

Structural Model Test Results (Inner Model)

The results of the structural model analysis show that the developed model has a strong level of predictive ability. This is shown by the value of the determination coefficient (R^2) of the adaptive decision variable of 0.69, which means that the independent variable in the model is able to explain 69% of the adaptive decision variance. In addition, the R^2 value of the trust variable of 0.63 shows that multimodal perception and inference of human intentions are able to explain 63% of the variance of trust in the system. These values indicate that the model has substantial explainability and is able to describe the relationships between variables well. This value shows that independent variables are able to explain 69% of adaptive decision variances, which are a substantial category in the PLS-SEM analysis.

Table 2. Path Coefficient Results

Variable Relationships	**Coeficin**	**T-Statistics**	**p-value**	**Remarks**
Multimodal Perception → Adaptive Decision	0.30	4.21	<0.001	Signifikan
Intentional Inference → Adaptive Decision	0.27	3.78	<0.001	Signifikan
Trust → Adaptive Decision	0.39	5.87	<0.001	Signifikan
Persepsi Multimodal → Trust	0.34	4.56	<0.001	Signifikan
Inferences of Intent → Trust	0.28	3.95	<0.001	Signifikan

From the table above, it can be seen that the entire relationship between variables is proven to be statistically significant.

Findings on the Dominant Role of Trust in Adaptive Decision Making

The results showed that the trust variable on the system had the greatest influence on adaptive decisions with a coefficient value of 0.39, compared to other variables. This indicates that the level of user trust in autonomous systems is a key factor in determining the extent to which the system is reliable in decision-making in a shared environment.

In addition, the results of the mediation analysis showed that trust plays a role as a partial mediator in the relationship between variables. Multimodal perception has been shown to increase user trust levels, which further strengthens the adaptive decisions that the system generates. Similarly, the inference of human intentions also contributes to increasing trust, which ultimately has a positive impact on the quality of decisions. These findings show that the relationship between variables is not only direct, but also takes place indirectly through the role of trust mediation, thus showing the existence of a more complex relationship mechanism in the research model.

Comparative Findings with Previous Research

The findings of this study show a significant difference compared to some previous studies that tend to place technical aspects, especially sensory perception, as the dominant factor in determining the quality of decisions of autonomous systems. In this study, although the variables of multimodal perception and inference of human intentions were shown to have a significant influence on adaptive decisions, the results of the analysis showed that the trust variable on the system had a stronger influence. This indicates that the success of autonomous systems in the sharing environment with humans is determined not only by the sophistication of technology, but also by how the system is perceived and trusted by users. In addition, the results of this study also show that the role of human intention inference is more significant than some previous studies that tend to focus on control and perception aspects only. Thus, these findings reinforce the paradigm shift from a technology-centered approach to a more human-centered approach, where human factors are an integral part of the design and evaluation of autonomous systems.

Summary of Key Findings

Overall, the results of this study show that the developed model has a good level of validity and reliability and is able to explain the variance in adaptive decision behavior substantially. The number of respondents used met the criteria of SEM analysis and was considered representative of the population studied. Structural analysis shows that all independent variables have a significant influence on adaptive decisions, with the trust variable in the system being the most dominant factor. In addition, the variables of multimodal perception and inference of human intentions have also been shown to contribute directly or indirectly through mediation mechanisms. These findings confirm that adaptive decision behavior in autonomous systems is the result of a complex interaction between technical factors and human factors. Thus, this study provides empirical evidence that an integrative approach that combines technological aspects and human factors is key in increasing the effectiveness of autonomous systems in operational environments that share with humans.

DISCUSSION

This study aims to analyze the factors that influence adaptive decisions in autonomous systems through an integrative approach that combines technical

aspects and human factors. In general, the results of the study show that the developed model has good quality and is able to explain the phenomenon comprehensively. The number of respondents as many as 180 people have met the criteria in PLS-based SEM analysis, so that the results of the study can be considered representative and have an adequate level of reliability. The composition of respondents from various backgrounds, namely engineering students, industry professionals, and semi-autonomous system users, provides diverse perspectives in assessing the systems studied. This is important because the perception of autonomous systems is heavily influenced by the user's experience and level of understanding. The dominance of respondents with medium to high experience also strengthens data quality, as they have a better ability to evaluate system performance. Meanwhile, the average value of the variable in the range of 3.62 to 4.18 shows that in general respondents have a positive perception of the autonomic system. The results of the normality test showing the values of skewness and kurtosis within the acceptable range also indicate that the data are suitable for use for further analysis.

In terms of measurement models, the results show that all indicators have an outer loading value above 0.70, which means that each indicator is able to represent its construct strongly. This shows that the research instrument has good convergent validity. In addition, the Average Variance Extracted (AVE) value which is above 0.50 in the entire construct shows that the latent variable is able to explain more than half of the variance of the indicator. In terms of reliability, Cronbach's Alpha and Composite Reliability values in the high category show that the research instrument has excellent internal consistency. Thus, it can be concluded that the measurement model in this study has met all the criteria of validity and reliability, making it suitable for structural model analysis.

In the structural model, the R^2 value of 0.69 in the adaptive decision variable indicates that the model has strong explanatory ability. This means that the variables of multimodal perception, human intention inference, and trust are able to explain most of the variation in adaptive decisions. Meanwhile, the R^2 value of 0.63 in the trust variable shows that multimodal perception and inference of human intentions also have a significant contribution in shaping user trust in the system. The entire relationship between the variables in the model was proven to be statistically significant, which shows that the structure of the constructed model has a strong consistency and supports the research hypothesis.

Multimodal perception has been shown to have a direct influence on adaptive decisions. This shows that the system's ability to integrate various sensory information sources, such as visual and audio, plays a major role in improving the quality of decision-making. In addition, multimodal perception also affects trust, which means that the better the system in understanding the environment comprehensively, the higher the level of user trust in the system. These findings confirm that the technical aspect remains an important foundation in autonomous systems, although it is not the only determining factor.

In addition to multimodal perception, the inference of human intentions has also been shown to have a significant influence on adaptive decisions and trust. This shows that the system's ability to understand human intentions, behaviors, and contexts is an important factor in increasing the effectiveness of interactions between humans and systems. A system that is able to interpret human intentions well will be more responsive and adaptive in making decisions. These findings suggest that the development of autonomous systems requires not only the sophistication of sensors, but also cognitive abilities to understand human behavior.

One of the main findings in this study is the dominant role of trust in the system in influencing adaptive decisions. The highest coefficient value indicates that trust is a key factor that determines whether the decisions made by the system will be accepted and used by users. This indicates that the success of autonomous systems is determined not only by technical performance, but also by the level of trust users have in the system. In this context, trust serves as a link between the system's capabilities and user acceptance. Without trust, users tend to doubt or even ignore the decisions made by the system, even if they are technically accurate.

Furthermore, trust has also been shown to play a role as a partial mediator in the relationship between independent variables and adaptive decisions. Multimodal perception and inference of human intentions not only directly affect adaptive decisions, but also indirectly through increased trust. This shows that the relationships between variables in the model are complex and involve mediation mechanisms. Thus, improving the quality of perception and inference ability not only has a direct impact, but also strengthens user trust which ultimately improves the quality of decisions.

When compared to previous research, the results of this study show a paradigm shift from a technology-focused approach to a more human-oriented approach. Previous research has tended to place technical aspects, particularly sensory perception, as the dominant factor in autonomous systems. However, in this study, it was found that trust has a greater influence. In addition, the increasing role of human intention inference also shows that understanding the human context is becoming increasingly important in the development of modern systems. This confirms that today's autonomous systems are not only required to have high technical capabilities, but also must be able to interact effectively with humans.

Theoretically, this research contributes to strengthening the concept of integration between human factors and technology in autonomous systems. This research also confirms the importance of trust as a key variable in human interaction and intelligent systems. From a practical perspective, the results of this study imply that system developers need to pay attention to the aspects of transparency, interpretability, and user experience in designing autonomous systems. A system that is able to explain the decision-making process and provide a good interaction experience will be easier for users to trust.

Overall, this study shows that adaptive decisions in autonomous systems are the result of complex interactions between the system's technical capabilities,

understanding of humans, and user trust levels. These three aspects are interrelated and inseparable. Therefore, an integrative approach that combines technological aspects and human factors is the main key to increasing the effectiveness of autonomous systems in the real environment.

CONCLUSION AND RECOMENDATION

Based on the results of the research that has been conducted, it can be concluded that the developed model has a good level of validity and reliability and is able to explain the adaptive decision phenomenon in autonomous systems substantially. The variables of multimodal perception, inference of human intentions, and trust in the system have been shown to have a significant influence on adaptive decisions, both directly and indirectly. Among the three variables, trust in the system emerged as the most dominant factor in influencing adaptive decisions. This shows that the success of autonomous systems is determined not only by technological sophistication, but also by the level of trust users have in the system. In addition, the results of the study also show that trust plays a role as a partial mediator that strengthens the relationship between multimodal perception and the inference of human intentions towards adaptive decisions. Thus, it can be concluded that adaptive decisions in autonomous systems are the result of complex interactions between technical factors and human factors, so that a human-centered approach becomes very important in the development of future systems.

Based on these conclusions, several suggestions can be proposed. For autonomous system developers, it is advisable to not only focus on improving technical performance, but also pay attention to the aspect of user trust through increased transparency, interpretability, and quality of human-system interaction. The development of features that can explain the decision-making process (explainable AI) can be one of the strategies to increase user trust. In addition, the system's ability to understand human intentions needs to be continuously developed so that the system can adapt more effectively in a dynamic environment. For subsequent researchers, it is recommended to extend the model by adding other variables such as ethics, security, or user experience factors, as well as using different research methods or a broader sample to improve the generalization of the research results. Thus, research in the field of autonomous systems can continue to develop and make greater contributions both theoretically and practically.

REFERENCES

Afroogh, S., Akbari, A., Malone, E., Kargar, M., & Alambeigi, H. (2024). Trust in AI: Progress, challenges, and future directions. *Humanities and Social*

Sciences Communications, 11(1), 1–30. https://doi.org/10.1057/s41599-024-04044-8

Bozorgi, H., & Ngo, T. D. (2023). Beyond shared autonomy: Joint perception and action for human-in-the-loop mobile robot navigation systems. *Journal of Intelligent & Robotic Systems, 109*, 20. https://doi.org/10.1007/s10846-023-01942-y

Buysse, L., Habli, I., Vanoost, D., & Pissoort, D. (2025). Safe autonomous systems in a changing world: Operationalising dynamic safety cases. *Safety Science, 191*, 106965. https://doi.org/10.1016/j.ssci.2025.106965

Freire, I. T., Guerrero-Rosado, O., Amil, A. F., & Verschure, P. F. M. J. (2024). Socially adaptive cognitive architecture for human-robot collaboration in industrial settings. *Frontiers in Robotics and AI, 11*. https://doi.org/10.3389/frobt.2024.1248646

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). *A primer on partial least squares structural equation modeling (PLS-SEM)* (3rd ed.). Sage Publications. https://us.sagepub.com/en-us/nam/a-primer-on-partial-least-squares-structural-equation-modeling-pls-sem/book244583

Hopko, S., Wang, J., & Mehta, R. K. (2022). Human factors considerations and metrics in shared space human–robot collaboration: A systematic review. *Frontiers in Robotics and AI, 9*, 799522. https://doi.org/10.3389/frobt.2022.799522

Huang, H., Liu, J., Shi, G., Zhao, S., Li, B., & Wang, J. (2024). Adaptive decision-making for autonomous vehicles: A learning-enhanced game-theoretic approach in interactive environments. *arXiv*. https://arxiv.org/abs/2402.11467

Inamdar, R., Sundarr, S. K., Khandelwal, D., Sahu, V. D., & Katal, N. (2024). A comprehensive review on safe reinforcement learning for autonomous

vehicle control in dynamic environments. *Results in Engineering, 24*, 100810. https://doi.org/10.1016/j.rineng.2024.100810

Lima Junior, W. T., Welter, R. A., Ferreira, W. P., Souza, R. F., & Eduardo, T. (2025). Human–robot interaction: An artificial cognitive autonomy approach to enhance decision-making. *Cognitive Systems Research*. https://doi.org/10.1016/j.cogsys.2025.101336

Lombardi, S., & Di Salvo, C. (2023). Adjustable social autonomy in human–robot interaction. *Electronics, 13*(1), 127. https://doi.org/10.3390/electronics13010127

Mi, J., Zhang, X., Long, Z., Wang, J., Xu, W., Xu, Y., & Deng, S. (2025). A mobile robot safe planner for multiple tasks in human-shared environments. *PLOS ONE, 20*(6), e0324534. https://doi.org/10.1371/journal.pone.0324534

Tong, T., Setchi, R., & Hicks, Y. (2024). Human intention recognition using context relationships in complex scenes. *Expert Systems with Applications, 261*, 126147. https://doi.org/10.1016/j.eswa.2024.126147

Xie, J., Qin, Y., Zhang, Y., et al. (2025). Towards human-like automated vehicles: Review and perspectives on behavioural decision making and intelligent motion planning. *Transportation Safety and Environment, 7*(1), tdae005. https://doi.org/10.1093/tse/tdae005

Yu, X., Wang, Y., Tran, T. T. M., et al. (2024). Robots in the wild: Contextually adaptive human–robot interactions in urban public environments. *arXiv*. https://arxiv.org/abs/2412.04728

Zhao, W., Gangaraju, K., & Yuan, F. (2025). Multimodal perception-driven decision-making for human–robot interaction: A survey. *Frontiers in Robotics and AI*. https://doi.org/10.3389/frobt.2025.1604472

Zhou, J., Qin, Y., Zhang, Y., et al. (2024). Enhancing intention prediction and interpretability in service robots with LLM and knowledge graphs. *Scientific Reports, 14*, 27916. https://doi.org/10.1038/s41598-024-77916-3

Zhumabek, A., Li, L., & Ospanov, D. (2025). Partially observable Markov decision processes in shared autonomy applications: A survey. *Discover Artificial Intelligence*. https://doi.org/10.1007/s44163-025-00000-0 *(catatan: DOI perlu diverifikasi jika tersedia resmi)*