

Asimovo

White paper / 2023

asimovo.com

How intelligent robotics will change our lives

Authors

Marieke Peeters
Christine Fraser
Aad Nales
Ludo Stellingwerff



Empowering robot development

This is the second white paper in our Asimovo series. In our previous white paper titled “Influencing the Future of Human-Robot Teaming,” we presented our visionary outlook on the future of robotics and the creation of high-performing human-robot teams. We emphasized the significance of integrating robots as an integral part of society and underscored the crucial role of human-robot teaming to ensure a seamless integration into everyday life. Building upon these ideas, this current paper delves deeper into Asimovo’s mission to empower robot development teams in their pursuit of constructing intelligent and collaborative robots.

“Within the realm of robotics development, Asimovo aims to provide comprehensive support and resources to enable the creation of advanced robotic systems.”

Our goal is to facilitate and empower robot development teams, assisting them in realizing their ambitions of building intelligent, collaborative robots that can seamlessly interact and cooperate with humans.

By leveraging our expertise and cutting-edge technologies, we offer a range of solutions designed to address the unique challenges faced by robot development teams. Through our platform, we provide an environment where multi-disciplinary teams can collaborate on robotics development projects, harnessing their collective skills and intelligence to propel robot development forward.

Asimovo’s platform integrates state-of-the-art tools, libraries, and frameworks that accelerate the development process, enabling teams to focus on innovating and refining their robotic systems. We provide advanced simulation capabilities that allow for realistic testing and validation of robot behavior in diverse scenarios.

Additionally, our platform seamlessly integrates artificial intelligence algorithms, empowering developers to imbue robots with intelligent capabilities such as perception, decision-making, and learning. Through the integration of AI, we envision a future where robots can adapt and learn from their interactions, continuously improving their performance and adaptability.

At Asimovo, we understand the importance of creating a harmonious collaboration between humans and robots. Our platform emphasizes human-centered design principles, ensuring that the robots developed are intuitive, safe, and capable of effectively augmenting human abilities.

Asimovo’s commitment extends beyond just the technological aspects of robot development.



We understand commercial sensitivities, as well as the need for shared learning. Some people want to share their learning only within their own organization or team. Others are happy to share their knowledge more openly.

At Asimovo we allow you to control your own IP and projects, and who has access to them. We build the functionality to operate in both open and closed asset libraries. We believe the user should decide how they want to collaborate.

However, we actively build platform functionality to foster a vibrant community of robot enthusiasts, experts, and stakeholders, encouraging knowledge sharing, best practices, and collective learning. By facilitating collaboration and exchange, we aim to cultivate an ecosystem that fuels innovation and drives the advancement of robotics.

In conclusion, this paper underscores Asimovo’s dedication to supporting robot development teams in their endeavors to construct intelligent and collaborative robots. Through our comprehensive platform, we aim to empower developers by providing them with the tools, resources, and community needed to overcome challenges and bring their visionary concepts to life. Together, we can shape a future where humans and robots coexist harmoniously, unlocking new possibilities and enriching society as a whole.

The mission / purpose

e.g. routine / non-routine, standardization / protocolization, impact, risks/hazards, dependencies, work cycles, time criticality, task decomposition, etc.

The application environment

e.g. predictable / unpredictable, collaborative / competitive,

The people involved

e.g. number, skill/expertise, health, etc.

The robots involved

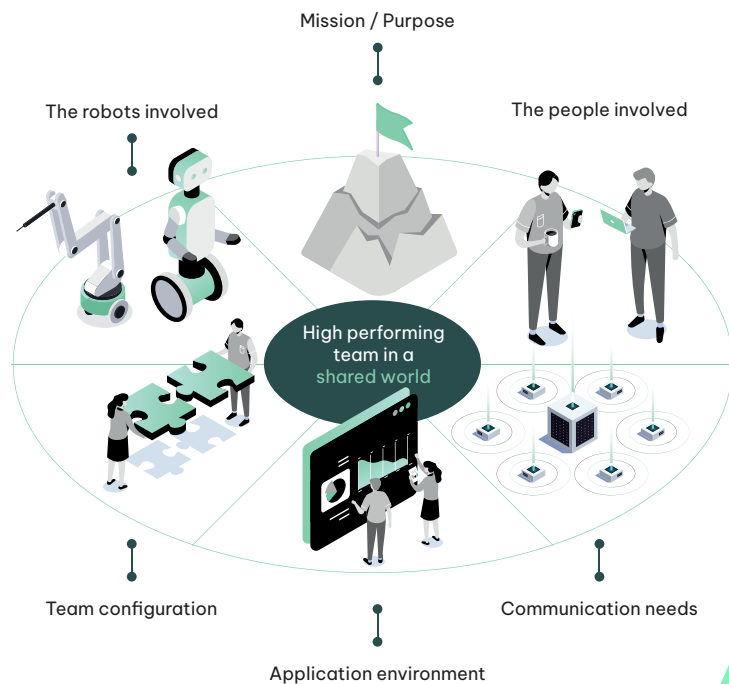
e.g. number, capabilities, physical proximity to other teammates,

Team dynamics and configuration

e.g. roles, rules, variability, communication, hierarchy/network structure, temporal scope, team maturity, responsibilities, etc.

The communication needs

e.g. streams (many-to-many, one-to-one, one-to-many, etc.), information richness, quality of infrastructure (bandwidth, reliability, range), continuity requirements (batch, live, other), etc.



The road ahead for intelligent robotics

We are currently on the verge of witnessing the convergence and simultaneous maturation of several groundbreaking technologies, each amplifying the strengths of the others. These technologies include advanced robotics and sensing, artificial intelligence (AI), simulation, and cloud computing. Let's delve into the developments and the power they unleash in each of these fields:



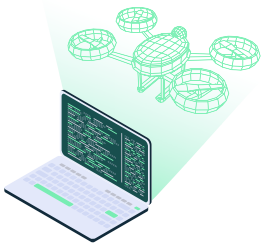
Advanced Robotics and Sensing:

Robotics has made significant strides, incorporating sophisticated sensors and actuators that enable precise movements and interactions with the environment. Sensing technologies such as vision systems, tactile sensors, and force feedback have advanced, enhancing robots' perception and interaction capabilities.



Artificial Intelligence:

AI has experienced remarkable progress, enabling machines to learn from data, reason, and make decisions. Machine learning algorithms, deep neural networks, reinforcement learning, and natural language processing have enabled AI systems to become more capable and adaptable.



Simulation:

Simulation technology has evolved, allowing researchers and engineers to create virtual environments that accurately represent real-world scenarios. These simulations enable testing and training of robotic systems, optimizing performance and reducing risks in real-world deployments.



Cloud Computing:

The growth of cloud computing has provided vast computational resources and storage capabilities. This allows robots and AI systems to leverage cloud-based infrastructure for processing large amounts of data, accessing advanced algorithms, running multiple simulations in parallel at hyperspeed, and sharing knowledge across multiple platforms.

The combination of these advancements will lead to a significant leap in the field of robotics, particularly towards intelligent robotics. By infusing robots with AI, we can create a new generation of robots that are collaborative, assistive, and cognitive, as Microsoft states in their quote: "Infusing advanced robotics with AI enables the next generation of robotics to be collaborative, assistive, and cognitive."



Looking ahead to the next five years, intelligent robotics holds tremendous potential in various use cases. Some examples include:

- 1. Building of the Future:** By leveraging IoT, data analytics, and AI, buildings of the future optimize energy efficiency, enhance occupant comfort, and integrate seamlessly with the surrounding infrastructure. Through the use of sensors, automation, and connectivity, smart buildings enable real-time monitoring and control of various systems, including lighting, HVAC, security, and occupancy management. They prioritize energy efficiency, occupant well-being, and safety, while facilitating connectivity with smart cities and offering personalized experiences
- 2. Construction Site of the Future:** Intelligent robots will assist with a range of tasks, such as heavy lifting, precise assembly, and hazardous operations, augmenting human capabilities and enhancing productivity. Construction sites will feature advanced robotic systems equipped with sensors and AI algorithms, allowing them to adapt to dynamic environments and work alongside human workers with precision and efficiency. Safety measures will be further improved through the utilization of intelligent robots capable of identifying potential hazards and actively preventing accidents.
- 3. Hospital of the Future:** Intelligent robots can support medical professionals by performing repetitive tasks, such as patient monitoring, medication delivery, and performing scans and tests. They can also enhance surgical procedures with improved precision, faster response times, and integration with medical data for real-time decision-making.
- 4. Urban Search and Rescue of the future:** Robots will play a vital role in augmenting the capabilities of human rescue teams, offering advanced sensing, mobility, and communication abilities. Equipped with AI algorithms and sophisticated sensors, intelligent collaborative robots will navigate complex and hazardous environments with precision and agility, identifying survivors, assessing structural integrity, and detecting potential dangers. These robots will possess the ability to communicate and collaborate with human responders, exchanging real-time information and coordinating rescue efforts. They will be capable of performing tasks such as debris removal, providing medical aid, and even carrying out delicate operations like extracting individuals trapped in confined spaces. Furthermore, these robots will leverage technologies like thermal imaging, advanced mapping, and autonomous decision-making to enhance situational awareness and optimize search and rescue strategies.

The combined capabilities of advanced robotics, AI, simulation, and cloud computing offer immense opportunities. These technologies can lead to increased productivity, improved safety, enhanced decision-making, and personalized experiences. However, along with these opportunities, several challenges and bottlenecks need to be addressed. Some of these include:

- Ethical Considerations:** As robots become more intelligent and autonomous, ethical questions surrounding their decision-making and potential impact on society must be carefully addressed. Ensuring fairness, accountability, and transparency in their actions is crucial.
- Privacy and Security:** With the integration of cloud computing and the collection of large amounts of data, maintaining privacy and protecting against cyber threats becomes paramount. Robust security measures must be in place to safeguard sensitive information and prevent unauthorized access.

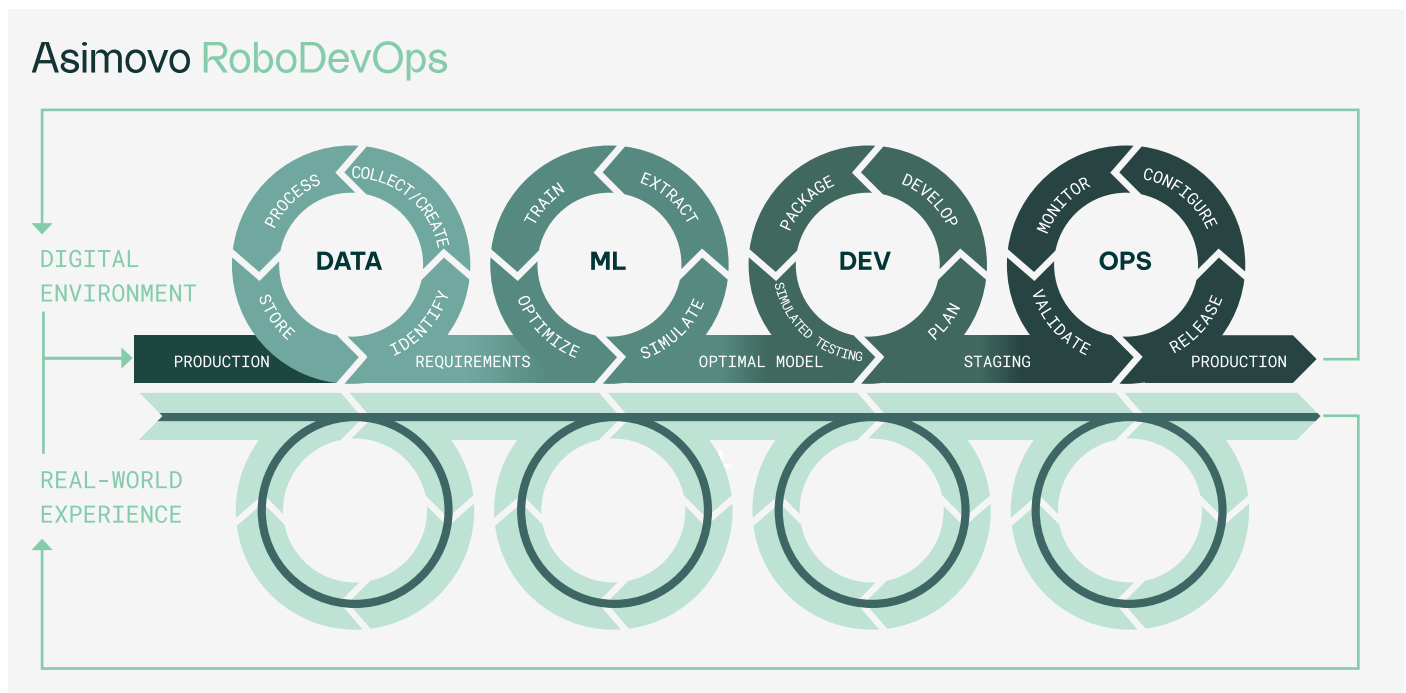
The convergence of advanced robotics, AI, simulation, and cloud computing will propel the field of robotics towards intelligent systems. The possibilities are vast, ranging from transforming the construction industry to revolutionizing healthcare. However, it is essential to navigate the challenges and ethical considerations to fully harness the potential of these technologies and build a future where intelligent robotics benefits society.



Essential needs for building intelligent collaborative robots

DevOps for robot development on the software side, particularly in the context of AI/ML, plays a crucial role in ensuring efficient and responsible development practices. Simulation environments, with the added element of human-AI collaboration, are integral to this process as they allow developers to test and refine AI/ML models while considering the interaction and collaboration between humans and AI systems.

“Building AI/ML models for robots follows a specialized process known as MLOps. This involves data collection, preprocessing, training, validation, and deployment of the models. Combine this with the ability to bring hardware into the loop and you create a new flow that we call RobDevOps.”



To facilitate this process, a robust development and testing environment is required. Simulation environments offer a scalable and cost-effective solution, enabling developers to access large datasets and leverage powerful computing resources. These virtual environments provide realistic representations of the physical world, allowing for the evaluation and fine-tuning of AI/ML models without the need for extensive physical deployments.



Depending on the maturity of the physical design, hardware can be brought into the testing loop at anytime. Adding real sensor data and output back into the digital simulation to understand and close the digital:reality gap. However for complex tasks this could be at a ratio of 90% simulation: 10% hardware in the loop. As you develop more autonomous behavior and develop behavioral models the hardware loop percentage will drop even further.

Simulation environments serve as a vital component of MLOps and RobDevOps, allowing developers to simulate real-world scenarios and evaluate the performance of AI/ML models. By testing the models in virtual environments, developers can gather valuable insights and iteratively refine the algorithms before deploying them on physical robots. Simulations enable developers to assess how the models interact with the environment, respond to various inputs, and make decisions. This iterative process helps optimize the models' performance, enhance their robustness, and identify potential limitations or edge cases.

In addition to AI/ML model development, simulation environments also contribute to responsible AI and responsible robotics. By simulating human-robot interactions, developers can evaluate the impact of AI decision-making on human operators and ensure the safety and well-being of users. Simulation environments provide a controlled space to test and refine algorithms, validate safety measures, and ensure compliance with ethical guidelines and regulatory requirements.

The inclusion of human-AI collaboration within simulation environments further enhances the development process. Human operators can interact with AI-powered robots, providing inputs, instructions, or feedback within the simulation environment. This enables developers to evaluate the effectiveness of communication, coordination, and decision-making between humans and intelligent robots, optimizing the overall human-robot interaction experience.

The absence of appropriate simulation environments can hinder the development process and prevent teams from fully leveraging the advancements described earlier. Without access to these environments, testing and refining AI/ML models become more challenging, as it would require costly and time-consuming physical deployments. Simulation environments are essential for efficient and iterative development cycles, enabling developers to detect and address issues early on, improving the overall reliability and performance of robotic systems.

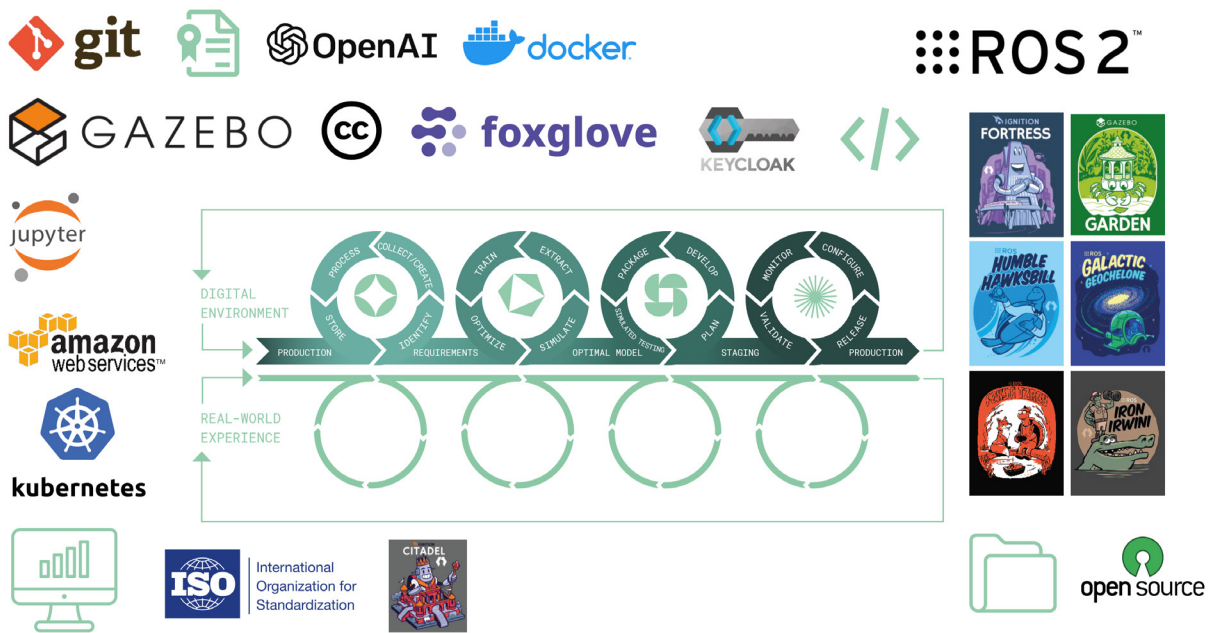


Asimovo helps you develop intelligent collaborative robots

Asimovo envisions a future where we aim to evolve alongside the advancements in intelligent robotics development and building. Our vision is to provide a comprehensive set of functionalities and tools that empower developers, end users, operators, and other stakeholders involved in the creation and deployment of intelligent robots.

The first step of this journey was to create a platform, where all the robotics tool-kit could be integrated, making it a great location for developing and testing. We started with the most widely adopted Robotics tools, and focused specifically on open source tools.

This diagram shows some of the ecosystem and tools that have already been integrated.

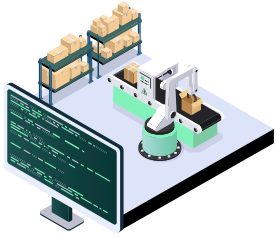


However the platform is only just getting started and there is a full roadmap for integrating more tools and features.

We have a number of strategic functionalities that will become a core part of the RobDevOps tool kit, and core features of the platform. These are namely:

- Scenario Planner
- World Builder
- Comprehensive Behavioral Library
- Standard Training Environments





Scenario Planner

At the heart of our future plans is the Scenario Planner, a powerful tool that will allow developers to design and simulate a wide range of scenarios in virtual environments. This will enable thorough testing and validation of AI/ML models, ensuring their robustness, adaptability, and compliance with ethical guidelines. The Scenario Planner will play a crucial role in the future evolution of the RobDevOps process, enabling developers to iteratively refine and optimize the behavior of intelligent robots.



World Builder

To support the development of realistic and immersive environments, our future plans include the World Builder, which will enable the creation of virtual spaces with intricate details and dynamic elements. This will allow developers to replicate real-world scenarios and train AI algorithms to effectively navigate and interact within different environments. We will also integrate the ability to use highly specialist partner tools for specific applications like high fidelity demonstration environments, or complex physics modeling.



Comprehensive Behaviour Library

Additionally, our future vision includes a comprehensive Behavioral Library, consisting of pre-built AI models and behavior modules that developers can leverage in their robot development process. This library will provide a foundation for building intelligent and context-aware robots, enabling them to understand and respond appropriately to various situations and human interactions.



Standard Training Environments

Recognizing the importance of training environments for both robots and humans, our future plans involve providing a range of simulation environments that include the potential to add human-controlled (VR/AR) or simulated avatars to facilitate human-robot interaction scenarios. These environments will allow developers to simulate and evaluate the performance of their AI models in realistic collaborative settings. Incorporating human-AI collaboration within these training environments will be a key focus, ensuring the development of robots that can effectively interact and collaborate with humans, and vice versa.



Asimovo helping pave the road forward

We have a number of strategic roadmaps that will add capabilities to the core platform and build value on top of those initial foundations.

Getting alignment across different application is important as we transition to deciding as a society what safety testing and regulation is needed before robots can interact with humans and public places. Our aim is to have a good enough combination of the above features that we can play a part in defining the final steps of autonomy and ensure we can build trust into the design and release of robots. Taking inspiration and guidance from responsible AI and building that into responsible RobDevOps

Team Performance functionality

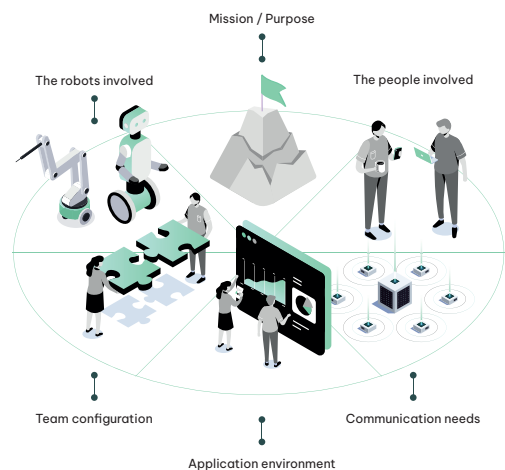
Tools for **Situational Awareness**

Tools for **H-R Collaboration**

Asset **Market place**

B2B Enterprise DevOps Solution

SAAS Platform for developers



High Performance Human-Robot teaming

Asimovo is committed to realizing this future vision of providing the required functionality for building intelligent robotics that can cater to the diverse needs of humans interacting with the robots. This includes developers, end users, operators, and other stakeholders involved in the deployment and operation of the robots. We aim to offer intuitive development tools, comprehensive documentation, and support resources to empower developers in building and customizing intelligent robots to suit specific use cases and requirements.



FUTURE WORKFLOW:

ROLES

- Robotics Engineer
- Human-Robot Collaboration Researcher
- Domain Experts
- End Users
- Operators
- AI/ML Engineer
- Robot Behavior Architect
- Scenario Builder
- Robot Tester
- World Builder
- Simulation Engineer

DEVELOPMENT

ROBOT BEHAVIOR DEVELOPMENT:

- Data Collection Or Generation
- Model Training
- Behavior Modeling
- Ontology Modeling

LIFECYCLE

SENSOR DATA PIPELINES

- Data collection or generation, potentially through simulation runs
- Sensor data pipelines
- Data cleanup
- Data transformations
- Data management
- Data-ontology mapping
- Data drift monitoring
- Automation scripts

SIMULATION DEVELOPMENT

- World building
- Scenario design and development
- Human-robot interaction possibilities (avatars / (G) UIs)

(COLLABORATIVE) BEHAVIOR MODEL

- Preparation
- Experimentation
- Model finetuning / transfer
- Model optimization
- Simulation modeling
- (Interactive / collaborative) simulation runs and testing
- Validations
- Evaluation metrics / criteria
- Automation scripts

BEHAVIOR MODEL DEPLOYMENT

- Scaled deployment
- Deployment monitoring
- Behavior monitoring
- Incident management and response
- Evaluation and monitoring scripts

DEVOPS

- CI/CD pipelines for (virtual) robot, simulation and (G)UI
- Testing/monitoring
- Logging
- Notifications
- Version control
- Model versioning
- Data versioning
- Robot versioning
- Orchestration

LIBRARIES

- Model libraries (behaviors, sensing capabilities, etc)
- Asset libraries (robots, sensors, actuators, worlds, objects, avatars, etc.)
- Dataset libraries
- Usage governance

IDENTITY MANAGEMENT

- Access control
- Rights
- Account management

GOVERNANCE

- Transparency
- Reporting
- Safety / security
- GDPR / AI act
- Compliance
- Ethics

Moreover, we recognize the importance of high-performing teams consisting of both humans and robots working collaboratively. As highlighted in a previous paper, our future ambition is to emphasize the importance of human-robot teaming and the integration of robots into various sectors and application domains. Ensuring that robots reach a level of maturation needed for high performing human-robot teams requires a clear understanding of the mission or purpose, identifying the specific roles and tasks for both robots and humans, determining the optimal team configuration, and addressing communication needs within the team. Our goal is to facilitate effective collaboration and communication between humans and robots, enabling seamless integration and maximizing the potential of these high-performing human-robot teams.

Asimovo's future vision is to evolve alongside the advancements in intelligent robotics development by providing a comprehensive set of functionalities and tools. The Scenario Planner, World Builder, Behavioral Library, and training environments will empower developers in the future to create and refine intelligent robots. We aspire to provide the required functionality to support diverse human interactions with robots, addressing the needs of developers, end users, operators, and other stakeholders. By facilitating human-robot collaboration and enabling effective team configuration and communication, we strive to contribute to the realization of high-performing teams of humans and robots in various mission scenarios.



Concluding statement

In conclusion, we are thrilled to be on the journey of building our dream of a future with intelligent robots. However, we recognize that we cannot achieve this vision alone. We extend an invitation to individuals and organizations to join us in this exciting endeavor.

Firstly, we invite our platform users to actively participate in our platform's development. Your invaluable feedback and insights will help us refine and enhance the functionality and user experience of our RobDevOps platform. Together, we can ensure that it meets the evolving needs of developers and users in building intelligent robots.

Additionally, we encourage contributors to share assets within the platform. Whether it's Gazebo worlds, digital twins of robots or sensors, or any other valuable resources, your contributions will enrich the ecosystem and enable other developers to access a diverse range of tools and environments for their robotics projects.

Furthermore, we seek research partners who share our passion for advancing the field of intelligent robotics. Collaborative efforts and knowledge-sharing will accelerate the development of innovative technologies and drive the adoption of responsible AI and responsible robotics practices.

By bringing together platform users, asset contributors, and research partners, we aspire to create the go-to RobDevOps platform that empowers robot developers and fuels the future of intelligent robots. Together, we can unlock new possibilities, shape the future of robotics, and revolutionize how humans and robots interact and collaborate.

We need good foundations for development and testing, and this then lets us expand further into the MLOps and ultimately RobDevOps.

Join us on this remarkable journey, and let's collectively build a future where intelligent robots become an integral part of our lives, transforming industries, and enhancing human experiences. Together, we will create a world where the potential of intelligent robotics is fully realized.



References

- <https://blog.mechanicalrock.io/2021/12/20/robot-devops.html>
- <https://news.aliasrobotics.com/secdevops/>
- <https://gurukannan.medium.com/overview-of-mlops-ml-dev-ops-2899ecb97820>
- <https://ml-ops.org/content/mlops-principles>
- <https://www.ml4devs.com/articles/mlops-machine-learning-life-cycle/>
- <https://blogs.nvidia.com/blog/2020/09/03/what-is-mlops/>
- <https://dlab.berkeley.edu/news/what-mlops-introduction-world-machine-learning-operations>
- <https://ubuntu.com/blog/what-is-mlops>
- <https://azure.microsoft.com/en-us/products/machine-learning/mlops/>
- <https://cloudxlab.com/blog/mlops-machine-learning-operations-a-complete-hands-on-guide-with-case-study/>
- <https://cloud.google.com/architecture/mlops-continuous-delivery-and-automation-pipelines-in-machine-learning>
- <https://aws.amazon.com/sagemaker/mlops/?sagemaker-data-wrangler-whats-new.sort-by=item.additionalFields.postDateTime&sagemaker-data-wrangler-whats-new.sort-order=desc>
- <https://www.databricks.com/glossary/mlops>

