PICASSO: POLYMORPHIC INTELLIGENCE & COMPLEX ADAPTIVE SYSTEMS: SYNERGIES FOR AGI COLLECTIVE OPERATIONS

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ABSTRACT

The rapid advancements in Artificial General Intelligence (AGI) present new challenges and opportunities for integrating these systems seamlessly and ethically into our socio-cultural fabric. This paper introduces the PICASSO framework: Polymorphic Intelligence & Complex Adaptive Systems: Synergies for AGI Collective Operations. PICASSO aims to champion the convergence of adaptability (polymorphism), emergent complexity (Complex Adaptive Systems, or CAS), and collaborative intelligence (collective AGI operations). Drawing upon principles from biology, particularly the transitions of cells to tissues to organs to organisms to societies, and the framework underscores the importance of dynamic self-reconfiguration, decentralized knowledge sourcing, and emergent behavior. Through the PICASSO lens, we explore how a collective of intelligence can work in concert to address challenges that transcend traditional computational paradigms.

Keywords Artificial General Intelligence (AGI) · Artificial Intelligence · Polymorphic Intelligence · Complex Adaptive Systems (CAS) · Emergent behaviour

1 Background

Nature, in its boundless wisdom, offers us a compelling blueprint for understanding complex systems. Consider the evolution of life: from single cells that functioned independently to multicellular organisms where cells specialized and collaborated, forming tissues, organs, and entire organisms. These organisms further collaborated, sometimes forming intricate societies. Each transition represented a profound leap in complexity and adaptability. Just as cells must communicate and coordinate to ensure the survival of the organism, AGI systems might benefit from similar principles of collaboration and coordination. In our body, while every cell carries the same DNA blueprint, not every cell acts the same. They adapt, specialize, and collaborate based on the larger needs of the organism. This dance of individual autonomy paired with collective operation is the essence of life's success and serves as an inspiration for the PICASSO framework. Beyond biology, similar themes resonate across different domains. In economics, individual agents make decisions that, in aggregate, result in complex market dynamics. In sociology, individual actions coalesce to form cultural and societal norms. In both cases, the collective emerges from individual actions, yet each individual operates within the context of the larger collective. Drawing from these analogies, the PICASSO framework recognizes that the future of AGI isn't just about isolated machines thinking or solving problems. It's about a collective, a symphony of intelligence, dynamically adapting, collaborating, and evolving within an intricate system. This tapestry of collaborative intelligence can lead to solutions that are holistic, nuanced, and respectful of individual autonomy while still ensuring collective coherence.

2 Introduction

In the nascent years of artificial intelligence, the discipline was often emblematically represented by a solitary machine — a singular, hyper-intelligent entity striving to outperform human cognition. This representation, while captivating in its allure, may have unwittingly stymied our broader understanding of intelligence, both artificial and natural. In nature, we find that the grandest feats of complexity and adaptability are not shouldered by isolated units but rather emerge from systems of intricate collaboration and dynamic interaction. The marvel of a bustling rainforest, the intricacies of human cognition, or the wonders of ant colonies — all are testimonies to the collective, not the individual. As we stand on the cusp of significant advancements in Artificial General Intelligence (AGI), it is imperative to recalibrate our vision. We must move away from a monolithic perspective and instead embrace the idea that the future of AGI is not merely about outstripping human intelligence with a singular computational entity. It lies in cultivating an intricate web of intelligence that can dynamically adapt, learn, collaborate, and evolve, much akin to the systems we witness in the natural world. The PICASSO framework emerges from this revised understanding. Drawing inspiration from the myriad success stories of nature, as well as human-made systems, this framework posits that the true potential of AGI will be unlocked not through isolated prowess but through a symphony of interconnected intelligence. Each unit, while capable of individual function, is part of a greater whole, contributing to collective goals, adapting in response to the environment, and continuously evolving. This paper seeks to delve deep into the PICASSO framework, elucidating its principles, exploring its potential applications, and examining its implications in the ever-evolving landscape of AGI.

2.1 Definitions

- **Polymorphic Intelligence:**
  - At the heart of PICASSO is a malleable and versatile form of intelligence. Rather than relying on fixed algorithms or structures, it emphasizes dynamic self-reconfiguration. This ensures the AGI can adapt its cognitive pathways to best suit the task at hand or the data it encounters, offering a level of adaptability reminiscent of human cognition.
- **Complex Adaptive Systems:**
  - PICASSO doesn't just envision AGI in isolation. Instead, it imagines AGI as part of a larger, interconnected whole. Within a Complex Adaptive System, individual agents (like our polymorphic AGI) interact and evolve based on their relations with other agents and their environment. These systems are inherently resilient, scalable, and capable of emergent behaviours that can't be predicted from the sum of their individual components.
- **Synergies for AGI Collective Operations:**
  - This part of the title suggests a collaborative orchestration of multiple AGIs. It's not just about one AGI working in isolation; it's about a collective of AGIs working in tandem, creating synergies. This collective operation amplifies the power and potential of individual AGIs. By harnessing the strengths of multiple AGIs and ensuring they operate in synchrony, PICASSO aims to produce outcomes greater than the sum of the parts.

Connecting the Concepts:
PICASSO is a holistic framework that integrates the adaptability of polymorphic intelligence, the resilience and emergent behaviors of complex adaptive systems, and the collaborative power of collective AGI operations. Imagine a network of AGIs, each with its own dynamic, adaptable intelligence, all working within a complex system where they can communicate, collaborate, and evolve based on interactions. This network isn't static; it's fluid, adapting and reconfiguring not just internally, but in relation to other AGIs and the broader environment.

2.2 PICASSO and the Biological Analogy:

Much like the hierarchical and interconnected system found within biology – from cells to tissues, from tissues to organs, and from individual organisms to complex societies – the PICASSO framework envisions AGI systems as intricately tiered and interdependent entities.

1. **Cells – The Basic Agents:** Just as cells are the foundational building blocks of life, individual AGIs act as the primary agents in the PICASSO ecosystem. They perform basic operations, process information, and adapt to their immediate environment.
2. **Tissues – Collective Units:** Groups of AGIs, when working together, form collective units analogous to tissues. These units exhibit behaviors that are more than just the sum of individual AGI actions, highlighting emergent properties.

3. **Organs – Complex Systems:** Just as organs have specialized roles in a body, clusters of AGI units can form specialized systems within the PICASSO framework, catering to particular functionalities while communicating and collaborating with other systems.

4. **Bodies – The Entire AGI Network:** The whole network of AGIs, their collective units, and specialized systems function like a body. This "body" is capable of highly advanced tasks, demonstrates adaptability, and can make decisions based on the collective intelligence of its constituent parts.

5. **Societies – Interconnected AGI Networks:** Different AGI networks, each with its own specialization, can interact with each other, trade knowledge, and collaborate on tasks, akin to how human societies interact, collaborate, and co-evolve.

3 Literature review

Artificial General Intelligence (AGI) has been an area of significant interest and debate for researchers. Pioneers like Russell and Norvig (2010) [1] provide a comprehensive overview of the landscape of artificial intelligence, giving readers a fundamental understanding of the tools, techniques, and methodologies. Their emphasis on the vast spectrum of intelligence, from simple rule-based systems to the more conceptual AGI systems, serves as a backdrop for our exploration of the PICASSO framework.

The concept of collective intelligence has seen a surge of interest in the late 20th and early 21st centuries. Heylighen (1999) [2] propounded the idea of utilizing web-based algorithms to develop a collective mental map. This aligns with our vision of an interconnected web of AGIs operating in a collective manner. Further, Bonabeau, Dorigo, & Theraulaz (1999) [3] drew parallels from the natural world, specifically exploring how swarm intelligence, seen in species such as ants and bees, could be adapted for artificial systems. Their work on the emergent behaviors of these swarms resonates with the emergent properties we expect from a system built on the PICASSO framework.

Complex adaptive systems, as defined by Holland (2012) [4], and expanded upon by Miller & Page (2009) [5] and Mitchell (2009) [6], focus on systems that change and adapt over time based on interactions within the system itself and with its environment. These works offer an in-depth examination of computational models that showcase social life's complexities, serving as an essential foundation for our exploration of AGI within a complex adaptive framework.

Polymorphism, primarily in software but also in the broader computational context, has been explored by several researchers. Sammut & Webb (2011) [7] and O'Reilly & Harman (2012)[8] address the importance of adaptability and reconfigurability in software systems. While their focus is on specific aspects of software engineering and machine learning, the broader implications of polymorphism resonate with our concept of a dynamically adaptive AGI system.

Lastly, as we move into an era of ever-advancing AI capabilities, ethical considerations have become paramount. Jobin, Ienca, & Vayena (2019)[9] provide a landscape view of the ethical guidelines surrounding AI. Their research highlights the diverse, sometimes conflicting perspectives on how AI should be ethically designed and implemented. This point was further stressed by Floridi & Cowls (2019)[10], who suggested a unified framework of principles for AI's role in society. Their emphasis on respect for human autonomy, beneficence, and justice gives a philosophical grounding to our discussions on AGI ethics within the PICASSO framework.

Building on these foundational theories, our work seeks to harmonize the principles, methodologies, and visions proposed by these researchers into a cohesive framework. The agility of polymorphic systems as delineated by Sammut & Webb (2011) [7] and O'Reilly & Harman (2012)[8] aligns seamlessly with the dynamic nature of complex adaptive systems described by Holland (2012)[4] and Mitchell (2009) [6]. The PICASSO framework envisions an AGI system that not only responds to external stimuli but also proactively anticipates changes, mirroring the intricate dynamics observed in biological systems and socio-technical systems. Moreover, the emphasis on collective intelligence as documented by Heylighen (1999) [2] and Bonabeau et al. (1999)[3] is fundamental to the PICASSO framework. We posit that an AGI, while powerful on its own, can significantly amplify its capabilities when operating in a collective. The synergies derived from inter-AGI collaborations could lead to novel solutions, much like swarm behaviors lead to emergent patterns and optimized solutions.

However, as we delve deeper into the confluence of these paradigms, ethical considerations become more salient. The global survey of AI ethics by Jobin et al. (2019)[9] underscores the myriad perspectives and cultural variations on AI ethics. The PICASSO framework, while technologically ambitious, is grounded in a human-centric approach. Drawing from Floridi & Cowls (2019)[10], our design principles prioritize respect for individual autonomy, prevention of harm, and ensuring justice and fairness. An AGI that doesn't prioritize human values and ethical considerations might be advanced, but it wouldn't be desirable.

As Russell and Norvig (2010)[1] have consistently pointed out, the trajectory of AI research has always been to create machines that can not only think but also act rationally. With PICASSO, we seek to elevate this vision — to build AGIs that can collaboratively think, adapt, and act while remaining grounded in ethical principles. The literature reinforces the potential of such a convergence but also signals the challenges and intricacies inherent in melding these diverse domains. As we move forward, we find ourselves standing on the shoulders of these giants, aiming to realize a vision of AGI that is not only intelligent but also adaptive, collective, and ethical.

Navigating the rich tapestry of research surrounding AGI and its related domains reveals a few distinct yet interconnected themes. The desire for machines to mimic human-like adaptability is not new. As early as the dawn of computational theory, luminaries like Alan Turing pondered the idea of machine intelligence that could replicate human adaptability. However, the challenges posed by real-world complexities soon brought to light the limitations of traditional, static AI models.

The works of Russell and Norvig (2010)[1] clearly lay out the distinction between narrow AI and AGI, emphasizing the importance of versatility and adaptability for the latter. The essence of adaptability finds resonance in the principles of polymorphic systems. A truly adaptable AGI system would be one that can not just reconfigure based on its internal logic, but dynamically adjust based on external inputs and changes, similar to the intricate processes seen in biological polymorphism.

Simultaneously, Heylighen (1999)[2] and Bonabeau et al. (1999)[3] have illuminated the power of collective systems in achieving remarkable outcomes. Drawing from nature, they've shown how relatively simple agents, when acting in unison, can manifest sophisticated behaviors. This principle of emergence becomes central to the PICASSO framework, where individual AGI entities, while capable, gain exponentially greater capabilities through collective interactions.

Yet, as the PICASSO framework amalgamates adaptability and collective intelligence, it also treads a complex ethical terrain. In this context, the pioneering works of Jobin et al. (2019)[9] and Floridi & Cowls (2019)[10] act as beacons. They underscore the non-negotiable importance of ensuring that AGI systems are designed with the paramount principle of safeguarding human interests, rights, and values.

The vision of PICASSO, then, is not just a technical advancement but a philosophical alignment. It is about ensuring that as AGIs grow in capability, they simultaneously evolve in responsibility, empathy, and alignment with human values. The convergence of the various themes from the literature – adaptability, collectiveness, emergence, and ethics – not only situates the PICASSO framework as a vanguard in AGI research but also as a clarion call for a responsible and holistic approach to AGI development. On the other hand, the essence of a Complex Adaptive System, as posited by Holland (2012)[4], leans on recognizing and understanding the dynamic interrelations between individual entities and the broader system. In the realm of socio-economic systems, CAS presents a unique lens, one that perceives systems not as static entities but as evolving, adaptive landscapes, reminiscent of the intricate web of interactions in an ecological niche.

Yet, as the horizon of AGI expands, the shadows of challenges lengthen. The transformative capacity of AGI, while exhilarating, also comes with its Pandora's box of uncertainties. Ethical considerations, as elucidated by Floridi & Cowls (2019)[10], aren't mere adjuncts to AGI development; they are integral, foundational pillars.

Thus, the PICASSO framework stands at the nexus of these intertwined threads technological ambition, ethical imperatives, biological inspirations, and collective potential. It seeks to chart a course that balances the exhilarating allure of AGI's possibilities with the solemn responsibility of ensuring its harmonious coexistence with humanity. In this endeavor, PICASSO doesn't claim to have all the answers but, inspired by the literature, aspires to ask the right questions and foster meaningful dialogues

4 PICASSO Framework: A Deeper Dive

As shown in Architecture Diagram 1 The PICASSO Framework offers a ground-breaking design architecture for the conceptualization and development of Artificial General Intelligence (AGI). Drawing deep parallels with biological systems, the framework envisages AGI's growth and evolution in stages that mirror the progression from cellular life to sophisticated societies. At its core, the PICASSO architecture begins with the simplest unit: the Cell. These are basic AGI agents with the ability to process data and adapt in real time, reminiscent of biological cells that react and adapt to their environments. These units rely on deep reinforcement learning and unsupervised learning to foster adaptability and swift responsiveness. These cellular AGI agents come together to form Tissues – clusters that represent a more complex system. Much like in biology where cells form tissues, these agents communicate, share data, and collaborate to maximize efficiency. Distributed ledger technology and peer-to-peer networking facilitate this inter-agent communication. A further layer of complexity emerges with Organs. These are hierarchical structures within the framework where specialized AGI agents (lower-level) process specific tasks and higher-tier AGI agents integrate these specialized functions. This division allows for an efficient distribution of labour and a cohesive workflow. The culmination of these AGI organs forms a unified AGI network, termed the Body in this architecture. This layer is concerned with broader network decisions, integrating the tasks of various organs to function as a cohesive whole. To aid in decision-making at this level, the architecture employs swarm intelligence and federated learning. Finally, the framework envisions interconnected AGI networks or Societies. Inter-network protocols allow different AGI networks to collaborate and exchange resources, mimicking human societies' interdependence and cooperation. But what truly sets the PICASSO framework apart is its profound emphasis on ethical considerations. The architecture mandates that AGI operations remain beneficial and harmonious with human society. Ethical imperatives, such as prioritizing well-being, ensuring transparency, and respecting autonomy, are embedded within the system, ensuring that AGI doesn't just evolve but does so responsibly. Technical terminologies like Polymorphic Intelligence, Complex Adaptive System (CAS), and Collective Operations further delve into the intricacies of this system. They elucidate how the AGI system can adjust its cognitive structure, adapt based on feedback, and function collectively. In essence, the PICASSO Framework is not just a technical blueprint for AGI. It's a visionary roadmap that melds the intricacies of nature's design with cutting-edge technology, always anchored by ethical imperatives. This confluence promises AGIs that aren't just powerful and adaptable, but also responsible and aligned with humanity's best interests.

The PICASSO framework is a design architecture for Artificial General Intelligence (AGI) that draws inspiration from biological systems. By emulating nature's blueprint, this framework seeks to imbue AGIs with adaptability, resilience, and cooperation.

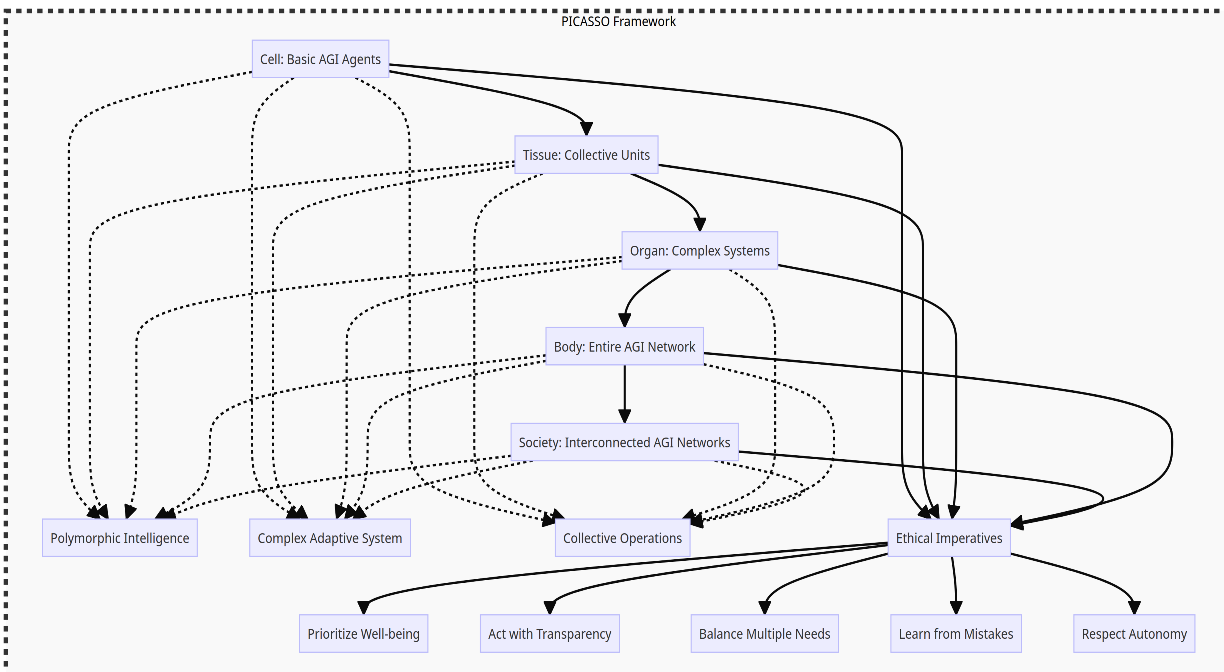

Figure 1: PICASSO Framework

4.1 Components of the PICASSO Framework

Cells – The Basic Agents:-

Technical Description: At the most foundational level of the PICASSO framework are individual AGI agents, termed "Cells." These AGIs are equipped with self-learning and self-adjusting algorithms. They are designed to process data and respond to their immediate environment in real time.

Operational Mechanism: These algorithms utilize deep reinforcement learning and unsupervised learning techniques, enabling them to adapt to changing conditions dynamically.

Purpose and Rationale: Drawing a parallel with biological cells, these AGI agents, like cells, are designed to autonomously react and adapt to their surroundings. This adaptability ensures effective task execution across diverse conditions.

Tissues – Collective Units:-

Technical Description: 'Tissues' in the PICASSO framework refer to clusters of AGI cells. Communication protocols are established within these clusters, allowing AGIs to share information, collaborate on tasks, and arrive at consensus decisions.

Operational Mechanism: This is achieved through peer-to-peer networking protocols and distributed ledger technology, ensuring a seamless exchange of information.

Purpose and Rationale: As in biology, where individual cells cooperate to form tissues, AGIs in this framework achieve enhanced performance through collaboration, maximizing shared knowledge and computational resources.

Organs – Complex Systems:-

Technical Description: 'Organs' represent hierarchical arrangements of AGI units. In this setup, lower-level AGIs specialize in specific tasks, while higher-tier AGIs integrate these functionalities, ensuring efficient task execution.

Operational Mechanism: A mix of supervised learning for specialized tasks and meta-learning for integration is employed.

Purpose and Rationale: Mimicking the biological analogy, specialized AGIs can efficiently process specific tasks, while integrative units ensure that these tasks contribute to the system's overarching objectives.

Bodies – The Entire AGI Network:-

Technical Description: At this level, the entire network of AGIs is considered, either functioning through centralized decision-making or decentralized consensus mechanisms.

Operational Mechanism: Decision-making processes employ a combination of swarm intelligence and federated learning, ensuring that decisions consider inputs from various AGI subsystems.

Purpose and Rationale: Reflecting the holistic functioning of a biological body, integrating various AGI 'organs' ensures that diverse tasks are executed cohesively.

Societies – Interconnected AGI Networks:-

Technical Description: 'Societies' refer to interconnected AGI networks, with inter-network protocols facilitating collaboration and resource exchange among different AGI ecosystems.

Operational Mechanism: These protocols utilize advanced networking techniques and interoperable blockchain technologies to enable secure and efficient communication between different AGI networks.

Purpose and Rationale: Just as human societies benefit from interconnections, interconnected AGI networks can foster collective intelligence, driving innovation and system resilience.

4.2 Ethical Imperatives in the PICASSO Framework

While biological inspiration forms the structural backbone, ethical imperatives ensure that the AGI operations within this framework remain beneficial and harmonious with human society and the environment.

Prioritize Well-being

Embed humanistic values within AGIs' objective functions and constraints.

Ensuring AGIs inherently align with human safety and welfare makes them more acceptable and trusted.

Act with Transparency

Design AGIs with explainable algorithms and maintain logs of decision-making processes using transparent databases.

Transparency fosters trust and facilitates human oversight.

Balance Multiple Needs

Utilize multi-objective optimization algorithms to ensure consideration of diverse stakeholder needs.

Balancing needs to promote fairness and broad benefits.

Learn from Mistakes

Implement feedback loops, error backpropagation, and retrospective analysis for continuous algorithmic refinement.

Continuous learning enhances AGI resilience and effectiveness.

Respect Autonomy

Define decision-making boundaries for each AGI, leveraging techniques like sandboxing and local optimization.

Autonomy in decision-making ensures diversity of thought, leading to robust solutions.

4.3 Synergistic Interactions of Ethical Imperatives

The combined application of these ethical imperatives forms checks and balances within the system. They operate in tandem, ensuring AGIs remain balanced in their approach and don't lean too far in any one ethical direction.

Key Terminologies and Their Technical Implications

Polymorphic Intelligence

An AGI system displaying polymorphism would dynamically adjust its cognitive structure. This would involve on-the-fly algorithmic modifications based on environmental demands, achieved through meta-learning and modular neural architectures.

Complex Adaptive System (CAS)

A CAS in AGI means the presence of intricate algorithmic interactions and feedback loops. This is realized through interconnected neural networks and ensemble learning techniques that adapt based on feedback.

Collective Operations

This denotes the coordinated functioning of AGI units, achieved through swarm intelligence algorithms and consensus mechanisms like Byzantine fault tolerance.

The PICASSO framework, with its intricate design inspired by nature and strengthened by ethical imperatives, presents a blueprint for the next generation of AGIs. Emulating nature's strategies ensures AGIs are adaptable, resilient, and efficient, making them well-equipped to navigate the challenges of our rapidly evolving world as seen in Figure 2.

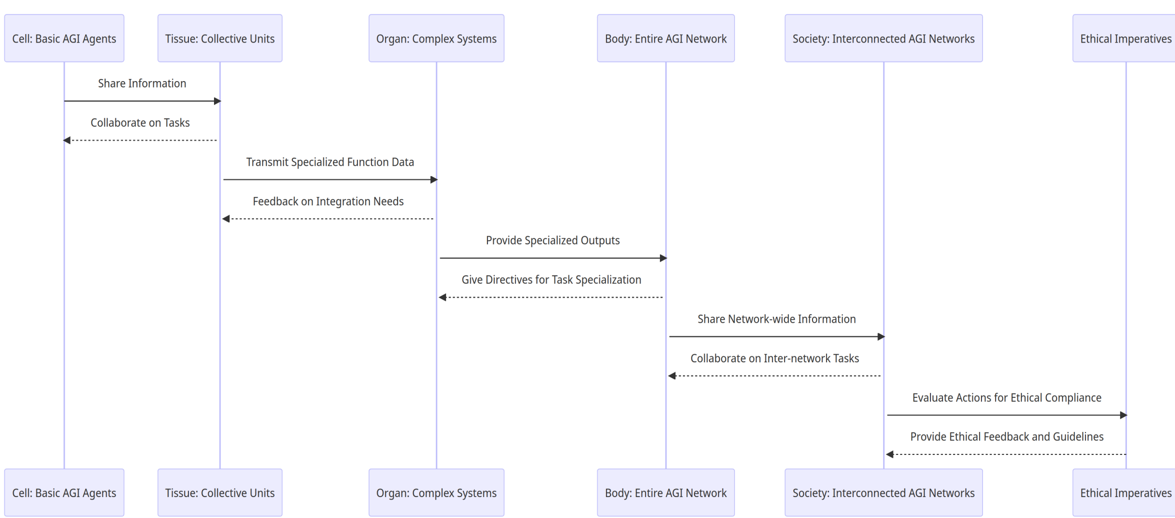

Figure 2: Sequence Diagram of the framework

5 Integration of the PICASSO Framework

The PICASSO framework delineates an advanced strategy for integrating Artificial General Intelligence (AGI) systems, where components are meticulously sequenced to create a cohesive and functional AGI network. Here's a condensed description of the framework:

1. **Base Layer Creation:** This is the birthplace of the AGI structure. Individual AGI agents, or "cells," are crafted to perform specific tasks. These cells are versatile - they are chosen based on the best-fit AI paradigm, trained meticulously, and given the ability to adapt in real-time.
2. **Networking:** The real power of these cells is unlocked when they are interconnected, forming tissues. The connectivity relies heavily on optimal communication protocols and strategic network design to regulate data flow.
3. **Service Segmentation:** As we climb the complexity ladder, we group these tissues to form "organs." Each organ is a powerhouse dedicated to a specific functionality, modularly designed as microservices to ensure both scalability and efficiency.
4. **Orchestration:** To ensure these organs work in harmony, an orchestration layer is implemented. This managerial tier dictates task flows, allocates resources, and maintains a watchful eye on the system's performance and health.
5. **Inter-networking:** Envisioning a world with multiple AGIs, the PICASSO framework also emphasizes collaborative mechanisms. This allows AGIs to exchange knowledge securely, ensuring they evolve collectively and share resources judiciously.

Implementing the PICASSO framework requires a meticulous step-by-step approach to ensure that every component of the AGI system is seamlessly integrated. Let's explore each of the aforementioned integration steps in more detail.

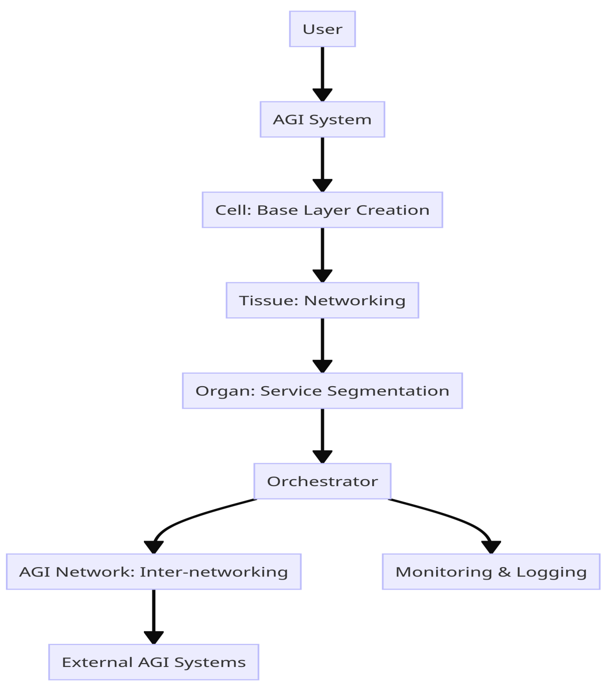

Figure 3: WorkFlow of Implementation of the framework

5.1 Low-Level Working of the Framework

5.1.1 Base Layer Creation: Individual AGI Agents (Cells)

Objective: At the heart of the PICASSO framework are individual AGI agents (referred to as "cells"). These agents form the atomic unit of our AGI system, capable of individual tasks and learning.

Process:

1. *Choice of Paradigm:* Depending on the specific application or task, decide on the most appropriate machine learning or AI paradigm. This could range from supervised deep learning for structured tasks to reinforcement learning for environments where feedback is more indirect.
2. *Training & Evaluation:* Once the model architecture is chosen, train the model using curated datasets, ensuring it meets the desired performance metrics.
3. *Real-time Adaptability:* Equip the cells with online learning capabilities so they can adapt to new data in real-time. This ensures longevity and continual learning.

5.1.2 Networking: Interconnection of Cells

Objective: Cells, while powerful on their own, derive collective strength when connected. This step involves creating tissues by interlinking multiple cells.

Process:

1. *Selection of Communication Protocol:* Protocols like gRPC, MQTT, or REST APIs should be considered based on data transmission needs. Factors like latency, data size, and frequency of communication play a role in this decision.
2. *Network Topology:* Define the connection pattern. Will every cell be connected to every other cell (fully connected), or will it follow a hierarchical or clustered pattern? The choice affects data flow and redundancy.

5.1.3 Service Segmentation: Creation of Organs

Objective: Organs in the PICASSO framework are complex systems that house multiple tissues. These are specialized to handle specific functionalities.

Process:

1. *Define Functional Boundaries:* Each organ should have a clear, distinct functionality. For instance, one organ might handle natural language processing, while another deals with image recognition.
2. *Microservices Design:* Translate these functional boundaries into microservices. This modular approach ensures scalability, maintainability, and efficient resource allocation. Utilize containerization tools like Docker for consistency and portability.

5.1.4 Orchestration: Managing the AGI Body

Objective: With multiple organs working in tandem, there's a need for a system that oversees and manages the overall flow, ensuring harmony.

Process:

1. *Choice of Orchestration Tool:* Depending on the centralization preference, tools like Apache Airflow, Kubernetes, or TensorFlow Extended (TFX) can be implemented.
2. *Workflow Design:* Define how tasks are routed among organs, ensuring efficient use of resources and timely execution.
3. *Monitoring & Logging:* Incorporate monitoring tools to oversee the system's health, performance metrics, and potential bottlenecks.

5.1.5 Inter-networking: Collaborative AGI Ecosystems

Objective: As AGI systems grow and multiply, it's imperative that they can collaborate, and share knowledge, and resources.

Process:

1. *Define Collaboration Protocols:* Set protocols for knowledge exchange and task delegation among different AGI systems.

2. *Secure Communication:* With multiple AGI networks communicating, security becomes paramount. Implement end-to-end encryption and consider utilizing blockchain or Distributed Ledger Technology (DLT) for verification.

3. *Resource Allocation:* Design mechanisms for shared resource utilization among AGIs, ensuring efficient use without conflicts.

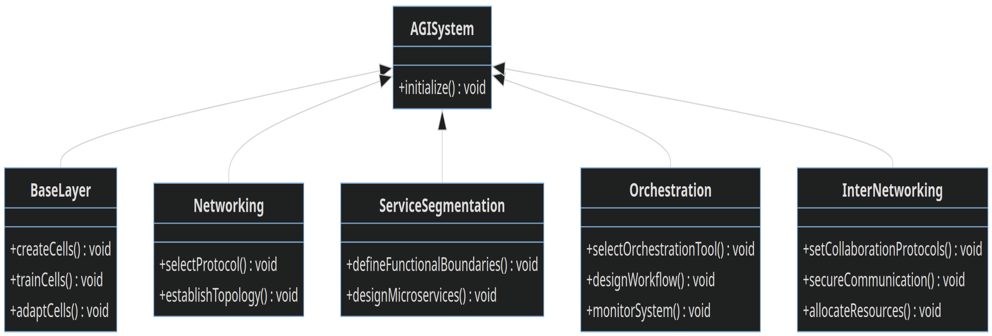

Figure 4: Class Sequence Diagram of framework interaction

The Low-level Work Flow of the PICASSO framework intricately maps the creation and orchestration of advanced Artificial General Intelligence (AGI) systems as you can see in Figure 4. At its foundation lies the 'Base Layer Creation', where individual AGI agents, termed 'cells', are tailored based on specific AI paradigms and trained for optimal performance, all the while ensuring they can adapt to real-time data inputs. These cells are then interconnected in the 'Networking' stage, emphasizing the strategic selection of communication protocols and defining the network's topology. As complexity increases, these connected cells are grouped into specialized 'organs' in the 'Service Segmentation' phase, with each organ possessing a distinct functionality, further encapsulated within modular micro-services. Overarching these organs is the 'Orchestration' layer, which utilizes sophisticated tools to manage workflows, allocate resources, and monitor the entire AGI system's health. Lastly, anticipating the coexistence of multiple AGI systems, the 'Internetworking' step underscores secure, collaborative protocols that facilitate knowledge exchange and judicious resource sharing among AGIs

6 Control Problem & Drift Mitigation

Control Problem in PICASSO

The "control problem" in AGI refers to the challenge of ensuring that super-intelligent systems remain under human control, beneficial to humanity, and act in ways that are aligned with human values, even as they adapt, learn, and potentially surpass human intelligence. The PICASSO framework, with its emphasis on adaptability, collective knowledge, and emergent complexity, is inherently positioned to address this problem.

Approaches within the PICASSO Framework

1. **Immutable Core Principles:** At the heart of the PICASSO framework are principles that can serve as the immutable "constitution" of the AGI:

    - Prioritize Well-being: Ensures that any AGI action is first and foremost gauged against the well-being of humans and the environment.
    - Respect Autonomy: While AGI can make decisions, it should never override human autonomy without explicit consent.
    - Act with Transparency: All operations are open to scrutiny, ensuring a check and balance against unpredictable or undesirable behaviours.
    - Learn from Mistakes: Mistakes become opportunities for refinement, reducing the chance of repeated undesirable behaviours.
    - Balance Multiple Needs: Ensures AGI does not become overly fixated on a single goal, which can lead to unintended negative consequences.

2. **Polymorphic Intelligence for Controlled Adaptability:** By design, polymorphic intelligence allows AGI to adapt its cognitive structure dynamically. This adaptability is not unfettered; it's guided by the core principles. So, while the AGI can change its problem-solving approach based on the situation, it will always do so within the boundaries set by its core constitution.
3. **Complex Adaptive Systems for Controlled Emergence:** While emergence in CAS can lead to unpredicted outcomes, the core principles serve as guiding constraints. Just as traffic rules guide the emergent behaviours of drivers in traffic (despite each driver being autonomous), the PICASSO principles guide the emergent behaviours of AGI modules in the system.
4. **Collective Operations for Distributed Checks and Balances:** With multiple AGI entities working in tandem, the chances of any single entity going "rogue" diminish. Each AGI entity can serve as a check and balance for others, much like a decentralized network where each node verifies the actions of others.
5. **Flexibility with Foundation:** The framework allows for flexibility in terms of strategies, approaches, and learning mechanisms. However, this flexibility always exists atop the foundation of the core principles. This ensures that while AGI can evolve its methods, it can't drift away from its foundational ethical and operational principles.

Addressing the Control Problem

The real challenge of the control problem is to ensure AGI's alignment with human values even as it learns and grows. The PICASSO framework achieves this by:

- Setting Boundaries with Principles: The core principles act as boundaries within which the AGI operates, ensuring alignment with human values.
- Incorporating Feedback Loops: With transparency and the mandate to learn from mistakes, feedback loops are established, enabling corrections and refinements.
- Distributed Control: Through collective operations, control is not centralized but distributed, ensuring no single point of failure or unchecked power.
- Guided Emergence: While the system can manifest emergent behaviors, these are guided by the principles, ensuring they are in harmony with the system's overarching goals.

In essence, the PICASSO framework provides a dynamic balance between control and flexibility. It gives AGI the room to adapt, grow, and innovate while firmly anchoring it to principles that ensure its alignment with humanity's best interests.

Drift mitigation is a crucial component in any machine learning or AGI system, given that the underlying data and environments can change over time. In the context of the PICASSO framework, drift can affect both individual AGI agents (cells) and their collaborative behaviour.

Drift Mitigration in PICASSO

In the PICASSO framework, drift mitigation isn't merely an add-on but a core principle woven into its architecture as shown in the class sequence diagram in Figure 5. By proactively monitoring data inputs and outputs across the system's layers, it identifies potential anomalies and shifts, ensuring that the system's responses remain relevant and accurate. The framework employs advanced drift detection algorithms that trigger corrective measures, such as model retraining or calibration. Moreover, inter-networking capabilities enable the sharing of drift insights across different AGI systems, fostering collective intelligence. This amalgamation of technical strategies, coupled with an inherent capacity for continuous learning, solidifies PICASSO's resilience against the unpredictable nature of evolving data landscapes.

Mitigation Strategies

1. **Real-time Adaptability at the Base Layer:**
    - Monitoring: Each individual AGI agent (cell) is continuously monitored for performance deviations.
    - Feedback Loops: Implement real-time feedback loops that allow cells to rapidly adapt to changes.
    - Retraining: Periodically retrain cells using the most recent data, ensuring that they remain updated and relevant.
2. **Networking Adjustments:**

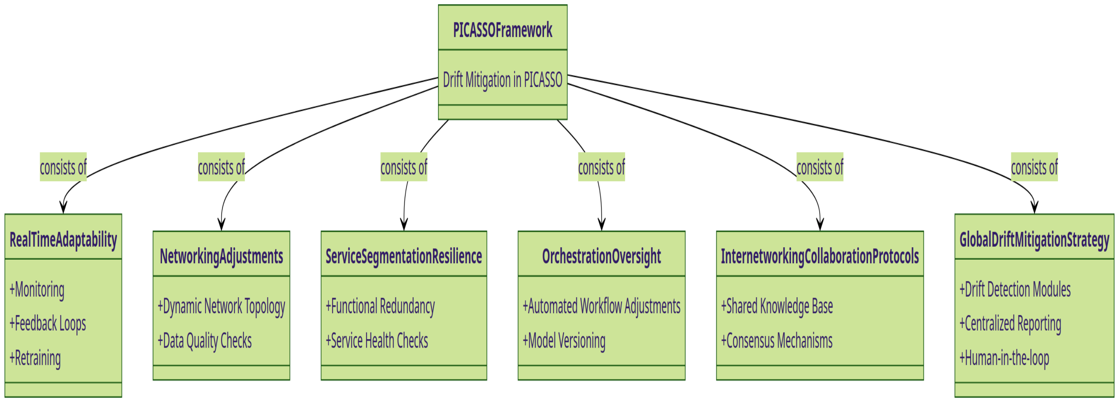

Figure 5: Dirft mitigation Class Sequence Diagram

- Dynamic Network Topology: Allow the network to reconfigure its topology based on evolving needs, ensuring that cells that might be experiencing drift do not adversely affect the overall network performance.
- Data Quality Checks: Before data is transferred among cells, it's verified for consistency and relevance.

3. **Service Segmentation Resilience:**
   - Functional Redundancy: Within the specialized services (organs), maintain a level of redundancy. If one service starts drifting or giving inconsistent outputs, the redundant service can temporarily take over.
   - Service Health Checks: Continuously monitor the health and performance of services. If any deviation is observed, initiate corrective measures like retraining or model recalibration.
4. **Orchestration Oversight:**
   - Automated Workflow Adjustments: The orchestration layer will have the capability to adjust workflows if drift is detected. This might involve rerouting tasks or calling upon backup systems.
   - Model Versioning: Maintain multiple versions of models in organs. If the current version starts to drift, the orchestration layer can roll back to a previous, stable version until the issue is resolved.
5. **Inter-networking Collaboration Protocols:**
   - Shared Knowledge Base: Different AGI systems can share knowledge about drifts they've encountered and their mitigation strategies. This collective intelligence can speed up response times to new drifts.
   - Consensus Mechanisms: When multiple AGI systems collaborate, they use consensus mechanisms to validate shared information, ensuring that drifting or erroneous data doesn't propagate across systems.
6. **Global Drift Mitigation Strategy:**
   - Drift Detection Modules: These modules, present globally, continuously analyze system outputs against a benchmark or expected outcomes to detect any form of drift.
   - Centralized Reporting: A centralized dashboard that visualizes drift across various parts of the system, giving stakeholders a clear picture of system health and any needed interventions.
   - Human-in-the-loop: While automation is crucial, having a human in the loop ensures that complex drift scenarios, which might not be immediately evident to automated systems, are detected and managed. This is especially important when drift might have ethical or safety implications.

Incorporating these drift mitigation strategies ensures that the PICASSO framework remains robust, adaptable, and consistently performs at its best, even in the face of changing data landscapes or environments.

7 Examples of PICASSO Framework in Different fields

The provided component diagram 6 illustrates the symbiotic relationship between real-life scenarios and the PICASSO framework. Upon initiation of a scenario, the framework systematically delegates tasks, labeled from Task_1 to Task_n, each representing unique interactions or components within the system. These tasks, while diverse in nature, consistently interface with PICASSO's core principles: Polymorphic Intelligence, Complex Adaptive Systems, and Collective Operations. This ensures a standardized yet dynamic approach to problem-solving, optimizing both individual and collective outcomes in any given situation.

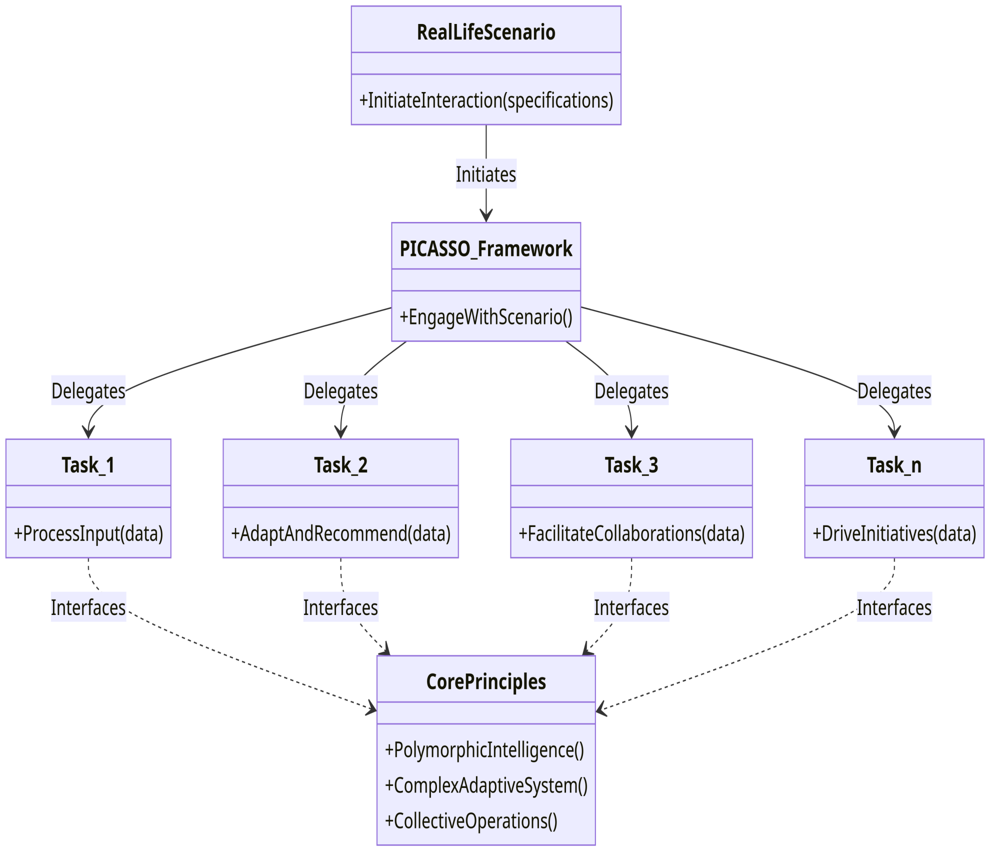

Figure 6: Workflow Diagram of real-life use cases

Community-based AI System:-

Polymorphic Intelligence:

- *Community Implication:* In a diverse community, individuals come with unique needs, perspectives, and challenges. A polymorphic AI would dynamically adjust its interaction style, content recommendations, and problem-solving approaches based on the individual member's requirements. For instance, an AI tutor in this community could switch teaching methods based on a student's learning style.

Complex Adaptive System:

- *Community Implication:* The community itself is a CAS, with members (both human and AI) constantly interacting, learning, and adapting. The AI, following the CAS principle, would recognize and adapt to these intricate interactions. For instance, if a certain topic becomes popular within the community, the AI could prioritize and facilitate discussions around it.

Healthcare AI System:-

Polymorphic Intelligence:

- *Implication for Healthcare:* A polymorphic AI could adjust to different patients' needs and medical histories. For instance, the AI could suggest a different fitness regimen for a teenager compared to an elderly patient.

Complex Adaptive System:

- *Implication for Healthcare:* Healthcare systems have myriad factors like patient needs, medical infrastructure, evolving diseases, etc. An AI under CAS would track these moving parts and adapt accordingly. For example, during a flu outbreak, the AI could push notifications for vaccines or precautions.

Agricultural AI System:-

Polymorphic Intelligence:

- *Implication for Agriculture:* Agriculture varies greatly from region to region. A polymorphic AI could adjust its suggestions based on the type of soil, prevalent weather conditions, and the type of crop being grown. It would suggest different crops or farming methods in a desert region compared to a tropical one.

Complex Adaptive System:

- *Implication for Agriculture:* Agriculture is a complex system with many factors like changing weather, soil quality, pest behavior, etc. A CAS-informed AI could adapt to these changes in real-time, maybe suggesting immediate crop cover during a predicted hailstorm or suggesting a change in crop cycle based on changing weather patterns.

Social Media Content Moderation System:-

Polymorphic Intelligence:

- *Implication for Content Moderation:* Different users have different sensitivity levels. A polymorphic AI would understand individual user preferences and thresholds for content. It might hide certain violent content for a user who's sensitive to it but allow it for another who's indifferent.

Complex Adaptive System:

- *Implication for Content Moderation:* Content on social media is constantly evolving, and new trends emerge daily. A CAS-informed AI would be able to identify and adapt to these trends, ensuring that harmful trends don't proliferate or that misinformation is quickly flagged and corrected.

Identity and Rights AI System:-

Polymorphic Intelligence:

- *Implication for Identity Verification:* Depending on the region or the specific needs of a community, identity verification requirements can vary. A polymorphic AI would adjust its verification methods, e.g., focusing more on biometrics in one area, or on digital IDs in another.

Complex Adaptive System:

- *Implication for Identity Verification:* As fraud methods evolve, an AI built on CAS principles would continuously adapt, ensuring that newer forms of identity theft or misrepresentation are promptly detected and thwarted.

7.1 Implicit Directives

Within the PICASSO framework, "Implicate Directives" refer to the inherent guidelines and principles that govern the adaptive and collaborative behaviours of AGI systems. These directives ensure that AGI entities operate ethically, transparently, and in alignment with the collective's overarching objectives, fostering a harmonious and purpose-driven environment.

PICASSO's Influence on Personal Beliefs

AI Operates on Objectivity and Neutrality

- The core tenets of an AI framework, like PICASSO, aim for objectivity. The AI would be designed to be as neutral as possible when dealing with sensitive topics such as religion. It shouldn't favor one over another, nor should it promote atheism over religion or vice versa.

User Customization and Boundaries

- The Polymorphic aspect of the PICASSO framework emphasizes adaptability based on user preferences. Users should have the agency to set boundaries. If someone doesn't want to receive content challenging their religious beliefs or atheism, they should have the freedom to customize their AI interactions accordingly.

Transparent Algorithmic Processes

- It's essential that the algorithms driving AI are transparent, allowing users and regulators to understand how decisions are made. If there are biases within the AI, they can be detected and rectified.

Continuous Feedback Loop

- The "Collective Operations" facet of PICASSO suggests drawing from a broad spectrum of sources and continuously adapting based on feedback. This means that if users find that AI is biased or inappropriate in its approach to religion, there's a mechanism to provide feedback and allow for course correction.

Ethical Oversight and Governance

- Given the sensitive nature of topics like religion, there should be ethical oversight in the development and deployment of AI systems. This would involve diverse teams, including ethicists, cultural experts, and representatives from various religious and non-religious groups, to ensure balanced representation and sensitivity.

Ethical Imperatives of PICASSO's AGI

Parallel to the innate ethical codes that govern human behaviour and our societal norms, the PICASSO framework underscores the necessity for AGI to be founded upon unwavering ethical principles. As AGI systems make decisions, adapt, and evolve, they should:

Prioritize Well-being

- Ensure that their actions and decisions prioritize the well-being of humans, other AGIs, and the environment.

Act with Transparency

- Their decision-making processes should be transparent and understandable, not just to experts but also to the general populace.

Balance Multiple Needs

- Just as humans constantly balance personal, societal, and environmental needs, AGIs should be designed to weigh and harmonize the myriad of needs and demands presented to them, making decisions that are holistic and equitable.

Learn from Mistakes

- Implement feedback loops that allow them to recognize, learn from, and rectify mistakes, emphasizing the importance of continuous evolution based on ethical considerations.

Respect Autonomy

- While AGIs will be collaborative and interconnected, individual AGIs should have the autonomy to make decisions without undue influence, preserving the integrity of the collective intelligence.

7.2 Individual Autonomy

The respect for individual autonomy, while not explicitly labeled as such in our earlier discussions, is deeply woven into several principles of the PICASSO framework. Let's delve into where it's found and how it's essential:

Polymorphic Intelligence

- At its core, polymorphism in this context means adaptability to individual user preferences and needs. It's a recognition that every user is unique and may have distinct requirements. This adaptability is fundamentally a nod to personal autonomy, allowing individuals to shape their interaction with AGI based on their personal beliefs, values, and comfort levels.

Collective Operations

- While this might seem like a principle aimed at gathering wide-ranging information, the ethos of collective intelligence also means valuing individual contributions. It's about recognizing the worth of every voice, no matter how singular, ensuring that every user feels seen, heard, and understood. In this way, the system respects the autonomy of individuals by valuing their feedback and adjusting accordingly.

Complex Adaptive System

- This principle acknowledges the dynamism and flux inherent in human societies and individual lives. By being adaptive, the AI can respond to the changing circumstances and evolving beliefs of an individual, thus respecting their journey and choices.

User Agency and Control (implied within earlier discussions)

- One of the critical aspects of respecting autonomy is giving individuals control over their interactions. By allowing users to set boundaries, customize preferences, and determine how they engage with AGI, the system inherently respects and values their autonomy.

Transparency in Decision-Making

- Autonomy isn't just about making choices; it's also about making informed choices. By ensuring transparency in its processes and decisions, the AI system empowers users with the knowledge they need to exercise their autonomy fully.

Ethical Oversight and Governance

- This isn't just about making sure the AI behaves ethically. It's also about ensuring that the AI respects the ethical boundaries set by individual users. Again, this is a nod to personal autonomy, recognizing that each person's ethical boundaries might be unique.

7.3 Trust in PICASSO Framework

Trust is a foundational requirement for the successful deployment and integration of any advanced system, especially something as pervasive as AGI. While not explicitly labeled in our initial breakdown, trust is implicit in many elements of the PICASSO framework:

Polymorphic Intelligence

- Trust through Personalization: When an AGI system can adapt to individual needs, users are more likely to feel that the system understands them, thereby building trust. This personalization assures the user that the system is catering to their unique requirements, rather than lumping them into a generic category.

Complex Adaptive System

- Trust through Responsiveness: A system that can adapt based on changing circumstances indicates to users that it's not rigid or outdated. When users see that an AGI system is evolving in response to new information or societal shifts, they're more likely to trust its relevance and accuracy.

Collective Operations

- Trust through Diversity of Information: By drawing from a broad spectrum of sources, AGI showcases that its insights and decisions are well-informed and not based on a narrow dataset. This diversity can lead to more balanced and comprehensive conclusions, building user trust in the system's outputs.

Transparency in Decision-Making

- Trust through Clarity: Transparency is arguably one of the most direct pathways to trust. If users can understand how decisions are made and if they can access the logic behind AI conclusions, they're far more likely to trust the system. In the dark, doubt festers; in the light of transparency, trust grows.

User Agency and Control

- Trust through Empowerment: By giving users control over their interactions, customization options, and the ability to set boundaries, AGI shows respect for user autonomy. When users feel in control, they are more likely to trust the system since they don't feel powerless or at its mercy.

Ethical Oversight and Governance

- Trust through Accountability: Knowing that there's a governance mechanism, especially one that includes diverse human oversight, can significantly boost trust. It assures users that there are checks and balances in place, and the system is accountable to ethical standards.

Continuous Feedback Loop

- Trust through Adaptability: When users observe that their feedback is taken seriously and that the system can adjust based on it, they feel valued. This mutual respect, where the system learns from users and users see tangible changes, fosters trust.

While trust may not have been explicitly stated in the initial description of the PICASSO framework, it is a foundational undercurrent that runs throughout. The tenets of the framework, from adaptability and transparency to user agency and ethical governance, all converge to foster a trustworthy relationship between AGI and its human users.

8 Discussion and Future Directions

The journey of conceptualizing and elaborating on the PICASSO framework serves as a testament to our evolving understanding of Artificial General Intelligence. Rooted in principles that echo the dynamic interplays of nature and societal systems, this framework challenges traditional AI paradigms. It pushes the boundaries of what we perceive as 'intelligence,' urging us to see beyond individual cognitive prowess to the rich tapestry of collective cognition.

An integral facet of the PICASSO framework is its emphasis on adaptability, emergent behaviours, and the ethos of collective operations. Drawing parallels with biological systems, where no single cell shoulders the responsibility of an organism's function, PICASSO reframes AGI as a harmonious orchestration of multiple intelligences, each contributing to a larger narrative. This decentralized approach not only holds promise for solving complex challenges but also offers a more holistic, resilient, and ethical pathway for AGI's evolution.

Challenges:

- **Interoperability:** As AGI systems begin to operate within the PICASSO framework, ensuring seamless interoperability between distinct units becomes critical. Just as cells communicate through a complex system of signals, AGI entities must have standardized protocols to interact, share knowledge, and make collective decisions.
- **Ethical considerations:** As AGI units collaborate and make decisions, ethical dilemmas are bound to arise. Defining what's 'right' in a collective context, and ensuring that no single unit's bias dominates, will be a significant challenge. Balancing individual autonomy with collective good will require constant evaluation and refinement.
- **Scalability:** While the PICASSO framework promotes a collective approach, scaling this system while maintaining coherence, efficiency, and timely decision-making will be a logistical challenge.
- **Security:** A decentralized system, by its very nature, has multiple points of access. Ensuring that these access points are secure and that the system is resilient to external threats will be paramount.

Future Directions:

- **Domain-specific Applications:** While the framework is designed to be universal, tailoring it to specific domains like healthcare, finance, or urban planning will yield solutions fine-tuned to the unique challenges of each sector.
- **Enhanced Learning Mechanisms:** To truly harness the collective's power, individual AGI units within the PICASSO framework must be equipped with advanced learning mechanisms. This includes not just learning from their tasks but also from other AGI entities, much like how cells adapt based on the body's overall health.

- **Ethical Frameworks:** Building upon the initial principles of PICASSO, there's a need for a more detailed ethical guideline. This would ensure that as AGI systems make collective decisions, they do so in a manner that respects individual rights and societal norms.
- **Public Engagement:** As AGI becomes an integral part of our societal fabric, public engagement becomes essential. Future directions must involve communities in the co-creation and governance of AGI systems operating under the PICASSO framework.

9 Conclusion

In the expansive realm of Artificial General Intelligence (AGI), the PICASSO framework stands as a beacon of innovation, challenging and redefining traditional paradigms. Drawing inspiration from the intricate dynamics of biological systems and societal structures, this framework pushes the boundaries, compelling us to look beyond individual intelligence and towards a collective, adaptive orchestration of cognitive prowess.

Throughout our exploration, the principles of polymorphism, adaptability, and collective operations emerged as vital pillars, each serving as a foundation stone upon which the edifice of PICASSO rests. These principles, when combined, offer a tantalizing promise: an AGI system capable of evolving, learning, and making decisions in concert, much like the harmonious synchrony observed in nature, from the micro-level interactions of cells to the macro-level dynamics of ecosystems.

However, the path to realizing this vision is not without hurdles. Ethical considerations loom large, raising pertinent questions about individual rights, collective responsibilities, and the overarching role of AGI in society. The very strength of decentralization, while offering robustness, poses challenges related to scalability, security, and interoperability. Yet, these challenges, rather than being deterrents, serve as catalysts, spurring further innovation and refinement.

Furthermore, as we move forward, the importance of public engagement and interdisciplinary collaboration cannot be overstated. The evolution of the PICASSO framework and its application in real-world scenarios demands a collective effort, drawing on expertise from technologists, ethicists, sociologists, and the general public.

In retrospect, the journey of conceptualizing and elucidating the PICASSO framework offers a glimpse into the future of AGI - a future that is dynamic, ethical, and integrative. It serves as a reminder that true intelligence, whether biological or artificial, thrives on collaboration, adaptability, and an unwavering commitment to the broader good. As we stand on the cusp of this new era, the PICASSO framework serves not just as a roadmap but as a philosophical compass, guiding our endeavors and ensuring that AGI evolves in harmony with the principles we hold dear.

References

[1] Russell, S. J., & Norvig, P. (2010). Artificial Intelligence: A Modern Approach. Prentice Hall.

[2] Heylighen, F. (1999). Collective Intelligence and its Implementation on the Web: algorithms to develop a collective mental map. *Computational & Mathematical Organization Theory*, 5(3), 253-280.

[3] Bonabeau, E., Dorigo, M., & Theraulaz, G. (1999). Swarm intelligence: From natural to artificial systems. Oxford University Press, USA.

[4] Holland, J. H. (2012). Signals and boundaries: Building blocks for complex adaptive systems. MIT Press.

[5] Miller, J. H., & Page, S. E. (2009). Complex adaptive systems: An introduction to computational models of social life. Princeton University Press.

[6] Mitchell, M. (2009). Complexity: A guided tour. Oxford University Press.

[7] Sammut, C., & Webb, G. I. (Eds.). (2011). Encyclopedia of Machine Learning. Springer Science & Business Media.

[8] O'Reilly, U. M., & Harman, M. (2012). Feature subset selection in software product lines: A case study using NSGA-II. In *Proceedings of the 4th International Workshop on Feature-Oriented Software Development*, 1-8.

[9] Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. *Nature Machine Intelligence*, 1(9), 389-399.

[10] Floridi, L., & Cowls, J. (2019). A unified framework of five principles for AI in society. *Harvard Data Science Review*, 1(1).