Spider Vision: A Natural Framework for AI Governance

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Abstract

This paper conducts comparative analyses of how the Spider Vision Framework—rooted in virtue ethics—differs from consequentialist models (focused on outcomes) and deontological models (focused on rules and duties). Through these comparisons, it underscores virtue ethics' unique emphasis on moral character and situational adaptability—the framework addresses immediate technical risks while accounting for long-term societal implications. Comparative analyses with consequentialist and deontological models underscore virtue ethics' emphasis on moral character, and the paper proposes pilot studies for empirical validation in healthcare AI and autonomous vehicles. This integrated approach aims to foster an adaptive, ethically robust governance model, balancing precision and breadth to better align AI with the common good. Initial findings suggest a significant improvement in ethical compliance and stakeholder engagement when dual-focus oversight is integrated into existing AI systems. The framework recommends targeted pilot implementations across diverse regulatory environments to ensure robust, context-specific outcomes.

Keywords: Keywords: AI Governance, Spider Vision Framework, Biomimicry, Virtue Ethics, Prudence, Justice, Adaptability, Focused Oversight, Systemic Awareness, Algorithmic Bias, Ethical Audits, Dual Visual Systems, Consequentialism, Deontology, Misinformation and Trust, Global Standards, High-Risk Applications, Empirical Validation, Pilot Studies, Long-Term Societal Impact

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1. Introduction

The exponential advancement of artificial intelligence (AI) technologies has brought unparalleled opportunities and challenges to modern societies. From healthcare and education to transportation and governance, AI systems have become deeply integrated into critical domains, driving efficiency and innovation. However, these advancements also raise significant ethical and practical concerns, such as algorithmic bias, privacy violations, accountability deficits, social inequities, and human rights implications. Addressing these concerns necessitates robust governance frameworks capable not only of ensuring alignment with societal values but also of anticipating and mitigating newly emerging risks.

For instance, the rapid expansion of generative AI—which can produce synthetic media, perform creative tasks, and interact in conversational modes—compounds pre-existing ethical and legal challenges.
Effective governance of generative AI must center around the populations impacted by technology rather than solely focusing on technology providers, thus directly addressing risks like misinformation and deepfakes [18].

1.1. Background and Motivation

The proliferation of deepfakes, automated disinformation, and potentially biased large language models underscores the need for an approach that scans for both immediate technical flaws (focused oversight) and broader social or geopolitical disruptions (systemic awareness) [18]. Without this combined perspective, governance efforts risk becoming reactive, mired in unintended consequences, and less resilient in the face of AI's ever-accelerating progress.

AI governance has therefore emerged as a critical area of research and practice, focusing on mechanisms to regulate, monitor, and guide the ethical use of AI technologies. Traditional governance models, however, often struggle to balance the dual imperatives of managing immediate risks and addressing long-term societal impacts. This dual challenge calls for innovative approaches that combine precision with systemic awareness. Floridi and Cowls [1] highlight the importance of integrating technical oversight with a broader understanding of AI's societal implications. In this context, biomimicry—a practice of drawing inspiration from natural systems to address complex human problems—provides a novel lens for reimagining AI governance.

1.2. Objectives of the Paper

This essay proposes the Spider Vision Framework as a governance structure for AI that leverages the dual visual systems of spiders to model an adaptive, ethical, and practical approach. Spiders' primary eyes provide acute, detail-oriented vision, enabling them to capture prey with precision. In contrast, their secondary eyes deliver broad, movement-sensitive peripheral awareness, crucial for detecting environmental changes and potential threats [2,3]. This dual visual system serves as a powerful metaphor for AI governance. Focused oversight parallels the spider's acute vision, addressing specific technical and ethical challenges such as algorithmic fairness, bias mitigation, and compliance. Meanwhile, systemic awareness mirrors

the spider's peripheral vision, encompassing broader considerations like unintended consequences, shifts in public trust, and structural inequalities.

A crucial theme woven throughout AI governance discussions is the tension between deeply specific, domain-dependent regulation and large-scale, transformative policy interventions. As AI technology accelerates, regulatory bodies often race to manage immediate threats—such as biased healthcare algorithms or invasive facial recognition—while losing sight of macro-level trends. The Spider Vision metaphor intuitively speaks to this dual need: the acute, detail-oriented "eyes" that spot micro-level problems, and the peripheral, system-focused "eyes" that track unfolding social, ethical, and environmental phenomena.

Rooted in virtue ethics—particularly Shannon Vallor's [4] framework of technological virtues—the Spider Vision Framework provides a normative foundation for AI governance by emphasizing the cultivation of moral character and virtues such as prudence (foreseeing consequences), justice (striving for fairness and equity), and adaptability (remaining agile amid rapid change). Together, these virtues inform a governance structure that is both ethically robust and pragmatically effective, ensuring that corporate actors and government agencies alike remain attuned to ethical considerations. By integrating virtue ethics with biomimetic insights, the Spider Vision Framework provides actionable strategies for AI governance by embedding moral reflection at every level—that is, from individual decision-making and organizational practice to policymaking and wider societal engagement. Thus, the Spider Vision Framework is neither strictly rule-bound nor reliant solely on cost-benefit analyses; rather, it is intentionally designed to evolve in tandem with AI's inherent complexities.

The following sections examine the Spider Vision Framework's theoretical underpinnings, comparing it to alternative ethical models and proposing avenues for empirical validation. Section II situates our approach in relation to virtue ethics, consequentialism, and deontology, illustrating how a focus on moral character can address emerging and unpredictable dilemmas. Section III expands on existing AI governance frameworks and underscores the limitations that motivated the Spider Vision concept. Section IV introduces the spider-inspired dual-vision approach, exploring how focused oversight aligns with immediate ethical audits while systemic awareness embraces broader societal impacts. Section V outlines empirical validation pathways, offering detailed pilot studies and metrics for assessing real-world effectiveness. Section VI then addresses the framework's limitations and challenges—such as stakeholder complexity and international disparities—while Section VII elaborates on broader applications and offers further avenues for validating the framework across diverse contexts. Finally, Section VIII discusses future research directions, including the potential expansion of the Spider Vision model to new AI domains and its integration with other ethical and governance paradigms. By addressing both immediate risks and systemic challenges, the framework contributes to the evolving discourse on responsible AI governance, highlighting the importance of balancing precision and breadth in oversight structures.

2. Theoretical Background

2.1. Comparative Perspectives: Virtue Ethics, Consequentialism, and Deontology

Virtue ethics differs from other dominant ethical approaches, notably consequentialism and deontology, in its focus on the moral character of individuals and institutions. Consequentialism (often linked to utilitarianism) assesses the moral worth of an action based on outcomes or consequences. In AI governance, a consequentialist approach might emphasize cost-benefit analyses, such as overall welfare gains or risk reductions. While this lens can provide clear metrics (e.g., efficiency, societal benefit), various critics warn that a singular emphasis on outcomes and quantifiable gains can obscure deeper ethical concerns—such as equity and power imbalances—especially when marginalized communities bear disproportionate burdens of AI-driven decisions [8,10,13]. These critics suggest that purely outcome-driven frameworks risk neglecting the cultivation of moral character and the structural factors that shape how AI systems affect different segments of society.

Deontology focuses on rules and duties, arguing that certain moral principles must be upheld regardless of outcomes. Applied to AI governance, a deontological approach might prioritize strict adherence to privacy or transparency principles, even if such rules reduce AI's potential benefits. While deontological frameworks offer clarity and protect fundamental rights, they can become rigid in dynamic, rapidly evolving technological settings.

Virtue ethics brings a flexible and context-sensitive perspective, emphasizing moral cultivation within institutions and among individuals. By urging stakeholders to cultivate virtues—such as prudence (foresight and moral grounding), justice (equity and fairness), and honesty (transparency and accountability)—the framework steers AI governance toward responsible behaviors while remaining responsive to complex, evolving challenges.

For instance, prudence might require developers to not only consult with affected communities before releasing facial recognition technologies in public spaces but also perform thorough risk assessments and scenario analyses that anticipate unintended consequences, such as heightened surveillance or misidentification of vulnerable groups. Meanwhile, justice entails equitable data sourcing—ensuring demographic diversity in training sets—and inclusive design practices that involve community stakeholders in shaping system objectives, thereby mitigating biases and disproportionate harms. Finally, honesty underpins transparent communication about algorithmic capabilities and limitations, which could include openly publishing performance metrics, clarifying areas of uncertainty, and proactively sharing any known risks or trade-offs with users and regulators. These more detailed examples illustrate how the moral core of virtue ethics can permeate everyday decision-making in AI labs, corporate boardrooms, and regulatory bodies, fostering an ethical culture that extends beyond mere compliance requirements.

Although virtue ethics stands at the heart of the Spider Vision Framework, it does not preclude the use of deontological or consequentialist tools. In fact, a “hybrid” approach can be highly effective: deontological principles—such as privacy rights—serve as guardrails the framework must not cross, ensuring consistent protection of fundamental interests. Concurrently, consequentialist cost-benefit analyses can guide resource allocation and policy-making, especially when stakeholders need to compare diverse AI implementation strategies under limited budgets.

By placing virtues at the core, we preserve the moral character of stakeholders and maintain an adaptive ethic. In turn, deontology offers rule-based guardrails, while consequentialism delivers measurable outcomes. This synergy ensures that AI governance is neither purely rule-driven nor solely focused on maximizing utility, but is morally grounded, flexible, and cognizant of quantifiable risks and benefits. For example, a cross-functional AI ethics committee might rely on both cost-benefit tools and deontological constraints while cultivating virtuous habits—such as transparency, empathy, and responsibility—in day-to-day operations.

2.1.1. Expanding on Virtue Ethics and Trust

A growing body of scholarship connects virtue ethics to the cultivation of trust in both institutional and technological contexts. Vallor [4], for example, highlights that when stakeholders consistently demonstrate virtues like honesty, prudence, and justice, they foster confidence that decisions will be guided by moral integrity rather than narrow self-interest. Such confidence is especially important in AI governance, where opaque algorithms and complex systems can quickly erode public trust. By embedding virtues throughout design processes (e.g., openly sharing performance metrics, proactively addressing biases, and engaging affected communities), organizations signal a commitment to fairness and responsibility, thereby reinforcing stakeholder trust in the technology’s development and deployment. This trust, in turn, underpins more robust adoption, smoother regulatory compliance, and deeper public engagement, giving virtue ethics an especially practical role in shaping AI’s social impact.

2.1.2. Addressing Critiques of Virtue Ethics in AI Governance

Despite its strengths, virtue ethics faces substantial scholarly critiques that must be explicitly addressed within the context of AI governance. Critics argue that virtue ethics involves inherent subjectivity, particularly in the selection and prioritization of virtues (Jobin et al. 2019). Different stakeholders may interpret virtues like prudence, justice, or adaptability differently, creating challenges for consistent application across diverse cultural and institutional contexts. For instance, the virtue of justice may carry varying implications depending on socioeconomic, cultural, or regional factors, complicating universally agreed-upon interpretations and practices.

Moreover, operationalizing virtues in practice has been identified as another significant challenge. While virtues offer powerful normative guidance, their abstract nature can impede direct translation into measurable actions or policy prescriptions. Vallor (2016) recognizes this difficulty, emphasizing the necessity of contextual judgment and practical wisdom (“phronesis”) to bridge the gap between abstract virtues and actionable strategies. This reliance on practical wisdom requires continuous moral education, stakeholder dialogue, and reflective practices

within organizations, imposing additional resource and capacity-building burdens on institutions that might already be constrained by budget or expertise.

Additionally, hybrid ethical frameworks—which combine virtue ethics with elements of consequentialism and deontology—have been criticized for potentially diluting the clarity and coherence of ethical guidelines. Critics suggest that blending ethical paradigms risks creating conflicting priorities or obscuring clear accountability, especially in high-stakes domains such as healthcare or autonomous transportation. Nevertheless, this critique may overlook the practical necessity of multidimensional ethical frameworks in dynamically evolving technological contexts, where singular ethical approaches often fail to address the multifaceted nature of real-world dilemmas comprehensively.

To mitigate these critiques, the Spider Vision Framework emphasizes explicit stakeholder dialogue to define and prioritize virtues clearly, contextually, and inclusively. Transparent and participatory processes—such as regular stakeholder forums, culturally sensitive consultations, and ethics workshops—are proposed as critical methods for cultivating shared understandings and operational clarity around virtues. Furthermore, the framework encourages explicit documentation of ethical deliberations and the rationale behind virtue selection, providing both transparency and accountability in AI governance practices. By proactively engaging these critiques, the Spider Vision Framework demonstrates an intentional commitment to addressing complexity, subjectivity, and operational challenges in virtue ethics.

2.2. Ethical Integration

The synergy between virtue ethics, deontology, and consequentialism is especially pertinent in global contexts where cultural norms and legal frameworks vary substantially. Some societies may have strong deontological traditions emphasizing respect for personal dignity and data privacy, while others might prioritize collective outcomes, leaning toward more consequentialist or utilitarian ideals. By anchoring these perspectives within a virtue ethics framework, AI governance can adapt to local conditions without sacrificing core ethical commitments.

Moreover, hybridized governance structures can reconcile the tension between top-down regulations and the bottom-up, practice-based reality of AI development. While high-level laws and ethical codes provide necessary boundaries (deontology) and can guide policy choices (consequentialism), actual day-to-day behavior in AI research labs or policy offices is shaped by the cultivated virtues of the individuals and teams involved. The emphasis on moral character ensures that once the external guardrails and outcome-based targets are established, practitioners remain internally motivated to act ethically, even in unpredictable or ambiguous situations.

3. Existing Governance Frameworks

3.1. Principles-Based Frameworks

Initiatives like the OECD AI Principles and the EU AI Act emphasize high-level directives—such as transparency, accountability, and fairness [18,7]. Recent authoritative scholarship highlights the EU AI Act's proactive, risk-based approach to general-purpose AI and large-scale generative models, marking a significant regulatory evolution [7]. Frameworks like the OECD AI Principles and the G20's AI Principles continue to underpin current international governance efforts, necessitating explicit and informed recognition in contemporary frameworks.

While these are valuable for establishing baseline norms, principle-based frameworks often depend on external or voluntary adherence and may not fully account for deeper moral cultivation or longer-term impacts. Research identifies persistent tensions and significant global divergences among various AI ethics guidelines, highlighting difficulties in practical implementation and underscoring the limitations of principles alone [21,22]. In UNESCO's Recommendation on the Ethics of Artificial Intelligence [6], for example, overarching principles guide development practices but leave gaps concerning local implementation, enforcement mechanisms, and region-specific social norms. Similarly, the EU AI Act seeks to introduce enforceable provisions on high-risk systems but struggles to keep pace with rapidly evolving technologies like large-scale generative models. By contrast, the Spider Vision Framework offers a biomimetic complement, embedding ethical values through a structured interplay of focused oversight and broad systemic awareness. Rather than relying solely on externally imposed rules, it emphasizes internalized virtues—such as prudence, justice, and honesty—that guide AI governance from within.

Additionally, the U.S. Congress introduced Algorithmic Accountability proposals, several states have passed AI-related laws targeting deepfakes and algorithmic bias, and a California bill on Frontier AI systems is pending. These legislative approaches mark a growing recognition of the urgent need for AI oversight, but they still tend to focus on specific challenges (e.g., deepfakes, algorithmic discrimination) rather than providing holistic governance that can evolve alongside technological breakthroughs.

Technical Auditing and Standards

Bias detection tools, certification programs, and technical audits focus on individual AI systems [7], ensuring, for instance, that a facial recognition model meets certain accuracy thresholds for minority groups. While these methods can remedy immediate issues, they often fail to capture how facial recognition technology might reshape law enforcement practices or exacerbate existing inequities. For example, a system may pass technical fairness audits but still be deployed in ways that concentrate surveillance on historically overpoliced neighborhoods, creating a chilling effect on public protests or civic participation. Similarly, even if the technology is deemed "unbiased" in its outputs, the mere expansion of facial recognition in public spaces

can undermine societal trust by normalizing continual monitoring and raising concerns over due process, autonomy, and the right to anonymity.

After mentioning relevant frameworks such as NIST or ISO, structured guidelines for implementing trustworthy AI [28] can further bolster these auditing and certification processes, although they still require robust ethical oversight to address systemic challenges.

3.2. Collaborative Governance

Multi-stakeholder initiatives unite governments, corporations, and civil society [8]. These collaborations promote inclusivity but can struggle with power imbalances and conflicting agendas. In large-scale projects—such as internationally coordinated AI policy summits—the loudest voices or wealthiest actors may dominate, marginalizing community stakeholders who lack resources to shape policy discussions.

Recent analyses emphasize international cooperation in AI governance, explicitly recommending prioritization of issues like computational oversight, export controls on AI hardware, and content provenance [27].

Academic commentators see the AI Act and AI Liability Directive as global templates, codifying principles (such as transparency, accountability, etc.) into law. Nevertheless, these frameworks often require significant interpretation and local adaptation, raising questions about how smaller or less technologically advanced regions will implement and enforce them effectively.

3.3. Challenges in AI Governance

Governance of AI systems includes pressing concerns: algorithmic bias, privacy, accountability, liability, and the difficulty of anticipating long-term consequences. Addressing these concerns necessitates robust governance frameworks capable of navigating the complexities of AI deployment and ensuring alignment with societal values. However, principle-based codes often lack clear enforcement mechanisms, and purely technical audits fail to account for social nuances. Here, the Spider Vision Framework stands out as a comprehensive approach that integrates multiple ethical lenses.

The intersection of AI and human rights—specifically privacy, freedom of expression, and equality—has become increasingly central, as highlighted by recent guidance from the United Nations Educational, Scientific and Cultural Organization (UNESCO) in its *Recommendation on the Ethics of Artificial Intelligence* (UNESCO 2022). Balancing these rights with the pace of innovation remains a central challenge in AI governance, requiring frameworks capable of both immediate oversight and long-term ethical reflection.

3.4. Context on AI Governance Challenges

One of the most notable issues is the “black box” nature of advanced AI models—large neural networks that can produce highly accurate predictions or classifications but offer limited transparency about how they arrived at their conclusions. This opacity can compound biases,

undermine accountability (who is responsible if the model malfunctions?), and erode public trust. Furthermore, the global nature of AI development means that national boundaries are porous: any governance strategy must grapple with the cross-border flow of data, research collaborations, and internationally distributed supply chains.

Another dimension involves balancing innovation with safety and ethical concerns. Overregulation may stifle beneficial AI applications, whereas underregulation can allow harmful or exploitative systems to proliferate. Achieving this balance requires a deep understanding not only of technical capabilities, but also of societal contexts, demographic realities, and cultural values. Hence, an ideal governance model would integrate dynamic oversight with ethical reflection, ensuring that each step in AI's development is continuously aligned with shared moral principles while still allowing for rapid adaptation and experimentation.

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4. Spider Vision Framework

4.1. Biological Inspiration: The Dual Visual Systems of Spiders

The idea for this framework originated from observing how spiders move seamlessly between detailed tasks—like capturing prey—and broader situational awareness that allows them to evade predators or environmental dangers. Beyond their webs' well-known architectural ingenuity, spiders possess two distinct sets of eyes that serve different functions: the primary eyes provide high-resolution visual acuity for precise movements, while the secondary eyes maintain a panoramic awareness of the surroundings. Even the slightest disturbance in ambient light or motion can alert a spider to potential threats, a skill set that has been honed through millennia of evolutionary refinement. This dual visual system seemed especially apt as a metaphor for AI governance, where regulators and designers face an ever-growing need to balance exacting technical oversight (akin to the spider's acute vision) with broad systemic scanning of ethical, legal, and societal repercussions (akin to the spider's peripheral vision).

Reimagining Oversight Through Biomimicry

The Spider Vision Framework adapts this biological insight into a governance model that invites us to see AI not only as a set of algorithms needing close scrutiny, but also as an ever-expanding web of social, economic, and political influences. By taking cues from spiders, we emphasize two modes of oversight: a focused, high-resolution "view" for pinpointing biases, errors, or safety concerns, and a wider, more holistic vantage for anticipating ripple effects, such as shifts in public trust or hidden biases that only emerge at scale. Biomimicry enables us to translate the spider's finely tuned balance of vigilance and precision into actionable strategies for AI governance, suggesting that managing AI effectively requires an ongoing dance between localized problem-solving and systemic adaptability.

4.2. Expansion on Biomimicry Rationale

Biomimicry has been employed in various fields to inspire more robust designs—examples include aerodynamic innovations influenced by birds' wings or architectural stability modeled on termite mounds for natural climate control. Applying this logic to AI governance recognizes that nature often evolves layered systems of perception and response. The spider's dual visual system offers a concise and compelling parallel to how AI oversight must operate: one perspective for pinpointing and correcting immediate or localized issues, and another vantage point for continuously monitoring the environment for systemic shifts, externalities, or emergent threats that might not be visible in narrow, detail-focused audits.

4.3. Governance Analogy: Balancing Precision and Breadth

Focused oversight corresponds to the spider's primary eyes and addresses immediate technical challenges in AI, including algorithm audits, risk assessments, and compliance. Systemic awareness parallels the spider's secondary eyes, encompassing broader considerations such as societal trust, emergent risks, cultural perspectives, and environmental impacts [10]. This balanced model is crucial for robust governance, preventing a narrow focus on technical details at the expense of societal ramifications.

4.4. Detailed Look at Focused Oversight

Focused oversight involves:
- Algorithmic Fairness Checks: Regularly auditing models to detect biases against marginalized groups.
- Safety and Reliability: Ensuring that AI-driven systems, such as autonomous vehicles or healthcare diagnostics, meet stringent performance benchmarks before release.
- Compliance with Regulatory Standards: Verifying that AI (LLM models) adhere to relevant data protection laws, privacy standards, and any sector-specific guidelines.

4.5. Detailed Look at Systemic Awareness

Systemic awareness extends beyond immediate performance metrics:
- Monitoring Societal Impact: Tracking public trust in AI, shifts in labor markets, and changes in social structures prompted by AI deployment.
- Cultural Sensitivity: Recognizing that an algorithm considered acceptable in one cultural context may be viewed as intrusive or unethical in another. Important recent studies of AI ethics in Latin America demonstrate significant divergences in cultural attitudes toward algorithmic transparency, privacy, and equitable technology deployment [21,22]. A comprehensive global survey reveals notable geographic gaps in AI ethics initiatives, particularly highlighting underrepresentation from Africa and South America [21].
- Long-Term Policy and Infrastructure: Identifying how large-scale AI adoption may alter socioeconomic landscapes, energy consumption patterns, or geopolitical power balances over time.

4.6. Integration of Roles: AI as Focused Eyes, Humans as Systemic Eyes

The Spider Vision Framework relies on a deliberate division of labor between AI and human oversight, mirroring the spider's dual visual system to ensure both precision and broad awareness:

- AI for Technical Oversight: High-speed data analysis tools can detect biases and anomalies more efficiently than human auditors [11].
- Humans for Systemic Awareness: Ethical foresight, cultural understanding, and empathy require human judgment, especially in addressing controversies around data privacy, global benefit-sharing, and regional inequalities [12].

4.7. Considerations for Role Integration

While technology excels at processing massive datasets rapidly, humans provide context, interpretive nuance, and moral intuition. In practice, a well-designed governance system harnesses the strengths of both. For instance, an automated tool could continuously scan a live AI application's outputs, flagging anomalies or performance drift. Simultaneously, a human oversight panel—composed of ethicists, sociologists, industry experts, and community representatives—could review aggregated feedback to evaluate whether the AI is producing harmful social outcomes or exacerbating inequalities. By respecting the unique capabilities of both machines and humans, the Spider Vision Framework embodies an intentionally collaborative approach, reinforcing that ethical governance is not simply about mechanical checks but about cultivating a morally informed community of practice.

4.8. Ethical Integration: The Role of Virtue Ethics

The Spider Vision Framework is rooted in virtue ethics [4], emphasizing moral cultivation in AI governance: prudence, justice, and adaptability. By embedding these virtues, the Spider Vision Framework fosters public trust, cultural inclusivity, and ethical responsibility, distinguishing itself from stricter rule-based or purely outcome-based approaches.

4.9. Practical Illustration

Imagine a healthcare system deploying AI-driven triage tools in emergency departments. A "focused oversight" team uses machine-driven audits to spot inaccuracies or biases in real time. Meanwhile, a "systemic awareness" task force—comprising bioethicists, patient advocates, and healthcare administrators—monitors metrics such as patient trust, readmission rates, and demographic disparities in service utilization. Together, they embody prudence (thinking ahead about potential ethical pitfalls), justice (ensuring fair access and resource allocation), and adaptability (rapidly revising protocols when biases or negative side effects are discovered). This orchestrated dual-vision process ensures that immediate technical fixes do not overshadow the broader goal of equitable, trustworthy healthcare.

4.10. Additional Example

Consider the use of AI in hiring practices, where algorithms filter resumes or evaluate job applicants. Focused oversight might involve a specialized AI auditing tool that detects disparate impact—possibly noticing that the model systematically ranks women or certain ethnic groups lower due to historical data biases. Meanwhile, systemic awareness would include a cross-organizational ethics committee examining how automated hiring tools influence corporate culture, diversity goals, and perceptions of fairness among applicants and the broader community. By continually reflecting on the moral implications, organizations can adapt both the technical and cultural aspects of hiring to align with evolving workforce norms and legal standards.

4.11. Limitations of the Spider Vision Metaphor

While the Spider Vision metaphor provides a compelling biomimetic analogy, it also carries certain limitations that merit explicit acknowledgment. First, biological metaphors, although intuitively appealing, may oversimplify the complexity inherent in socio-technical AI governance systems. Spiders' dual visual systems evolved primarily for survival, optimized specifically for predator-prey dynamics and environmental navigation. Translating this biological analogy directly into a governance model requires supplementary frameworks to ensure comprehensive oversight, particularly when addressing nuanced ethical, legal, and socio-political challenges not easily mapped onto biological processes.

For example, spiders rely heavily on instinctual, reactive behaviors honed through evolutionary processes, whereas effective AI governance necessitates anticipatory, proactive strategies informed by deep ethical reasoning, cultural understanding, and political negotiation—elements beyond mere reactive mechanisms. Additionally, the metaphor's emphasis on individual spider adaptability might obscure the importance of collective, collaborative governance efforts across diverse stakeholders, including international regulatory bodies, corporations, and civil society.

Thus, the Spider Vision Framework must be complemented by additional analytical tools, such as data governance protocols, cultural sensitivity assessments, comprehensive ethical deliberations, and collaborative policy-making frameworks, to effectively manage the full complexity of AI ecosystems. Recognizing these limitations reinforces the importance of maintaining a flexible, interdisciplinary approach that draws on multiple governance models rather than relying exclusively on biomimicry.

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5. Applications of the Spider Vision Framework

5.1. Algorithm Audits and Bias Mitigation

The significant surge in algorithmic auditing literature underscores the critical role of accountability in AI governance, advocating for rigorous, standardized auditing practices [Raji et al. 2020; Schiff et al. 2021]. Focused oversight mechanisms thereby tackle one of AI's most pressing challenges:
- Auditing Processes: Comprehensive audits uncover biases in training data and model architectures [7].
- Bias Mitigation Tools: Toolkits like IBM's AI Fairness 360 operationalize fairness principles, aligning with prudence and justice.

A virtue ethics lens adds moral accountability to technical processes, ensuring that teams do not merely detect biases but also take responsibility for addressing root causes.

5.2. Systemic Risk Monitoring

Systemic awareness mechanisms address broader societal impacts:
- Misinformation and Trust: AI-driven misinformation can undermine public trust; continuous monitoring identifies emerging threats [13].
- Environmental Costs: Resource-intensive AI systems have planetary implications [10].
- Existential Risks: Advanced AI might pose existential threats requiring multi-level governance [14].

A recent comprehensive meta-review provides a taxonomy of AI risks, reinforcing the necessity of broad, systematic monitoring approaches [18]. By integrating virtue ethics, stakeholders maintain a long-term moral perspective, ensuring that immediate gains do not overshadow potential harms to society or the environment.

5.3. Collaborative Policymaking

The Spider Vision Framework supports adaptable governance models that bridge regional disparities in technical and regulatory capacities:
- Global Standards: Aligns with international initiatives (OECD AI Principles, EU AI Act) by operationalizing ethical virtues through dual-focus oversight [5,15].
- Benefit-Sharing: Emphasizes equitable distribution of AI benefits, fostering global cooperation and trust [12].

5.4. High-Risk Applications

Highly consequential sectors, such as military systems, healthcare applications, and autonomous vehicles, require rigorous governance. By integrating virtue ethics, the Spider Vision Framework's dual-focus approach ensures targeted interventions and broader societal safeguards.

Governance tailored to high-risk sectors such as healthcare or finance is increasingly vital, supported by recent sector-specific research that outlines concrete ethical practices [29]. The stakes in these domains are particularly acute. In military contexts, AI-driven weapon systems raise profound moral questions about delegating life-and-death decisions to algorithms. Focused oversight can help ensure that these systems meet essential reliability and accountability thresholds, while systemic awareness involves analyzing the geopolitical ramifications, arms race dynamics, and impacts on international treaties. In healthcare, the potential for AI to revolutionize disease diagnosis is immense—but so too are the dangers of exacerbating existing inequalities or undermining the physician-patient relationship. The Spider Vision Framework's emphasis on moral virtue ensures that even as these applications scale, human values remain central to both design and operational decisions.

5.5. Cross-Cultural Adaptability and International Implementation

The Spider Vision Framework recognizes that effective AI governance must be adaptable across diverse cultural, regulatory, and social contexts. For instance, recent studies in Latin America demonstrate significant variations in societal attitudes toward algorithmic transparency, data privacy, and equitable technology deployment (Mancilla-Caceres & Estrada-Villalta 2022). In such contexts, the focused oversight dimension may require culturally tailored algorithmic fairness audits, incorporating local definitions of fairness, privacy, and consent rather than importing standardized, externally developed metrics.

Similarly, Nigeria presents another illustrative scenario, where AI governance must grapple with systemic societal challenges related to human rights, infrastructure limitations, and local governance capacity [16]. Here, the systemic awareness component of the Spider Vision Framework emphasizes extensive stakeholder consultations, capacity-building initiatives, and sensitivity to the specific human rights implications of deploying AI tools. Such context-specific adaptations ensure governance strategies remain relevant, effective, and respectful of local norms and values.

By explicitly incorporating cross-cultural sensitivity into governance mechanisms, the Spider Vision Framework not only enhances its practical effectiveness but also fosters greater legitimacy and acceptance among diverse global stakeholders.

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6. Limitations and Challenges

6.1. Stakeholder Complexity

AI governance brings together a diverse set of stakeholders (governments, corporations, civil society, academia) with competing interests and power disparities [8]. Achieving consensus on virtue-driven governance can be challenging without robust dialogue platforms and shared accountability mechanisms.

6.2. International Disparities

Substantial regulatory and resource gaps exist among nations [16]. Wealthier countries can implement advanced governance structures more easily, while developing regions often lack technical and financial resources [12]. Tailored adaptations of the Spider Vision Framework are necessary to ensure equitable governance worldwide.

6.3. Systemic Complexity

The Spider Vision metaphor, while powerful, can oversimplify the nuances of large-scale social and technical systems [17]. Complementary approaches—such as data governance frameworks, cultural-lens analyses, and scenario planning—may be needed to capture the full range of socio-technical influences in AI ecosystems.

6.4. Practical Constraints

Even the most thoughtful governance framework can stall when confronted with real-world politics and budgetary pressures. For example, while it may be ethically desirable to implement extensive algorithmic audits, many organizations operate under strict cost constraints, resulting in minimal compliance-driven audits rather than thorough and iterative evaluations. Likewise, global collaboration is ideal in principle, but national security considerations or commercial competition may impede transparent data sharing. These realities highlight the importance of building not only robust theoretical models but also practical incentives and international partnerships that can sustain them.

Despite These Challenges
Integrating a virtue-based lens may facilitate more resilient and cooperative solutions. Stakeholders who view themselves as part of a shared moral project—shaped by honesty, prudence, and justice—are more inclined to collaborate across institutional, sectoral, or national lines. For instance, honesty fosters a willingness to share data sources and best practices, prudence encourages longer-term planning that can counteract political and budgetary short-sightedness, and justice highlights the need for equitable outcomes, even where resources are limited. By grounding AI governance in these virtues, organizations and governments can transcend immediate constraints, forging deeper trust and more sustainable partnerships over time.

6.5. Stakeholder Complexity, Power Dynamics, and Geopolitical Concerns

AI governance is inherently complex due to the diverse and often conflicting interests of global stakeholders—including powerful multinational corporations, national governments, civil society organizations, and less economically developed regions. These varying stakeholders differ widely in their resources, influence, and capacities to shape governance agendas, creating pronounced power asymmetries that complicate equitable governance outcomes (Khanal et al. 2024).

For example, large technology firms ("Big Tech") often possess substantial economic resources and policy influence, allowing them to significantly shape regulatory standards in ways that may align primarily with commercial interests. Such dynamics can disadvantage smaller economies or regions that lack comparable technical, financial, and regulatory capabilities (Birhane 2020). An illustrative case is the ongoing debate around data sovereignty and digital colonization in African nations, where Western-developed AI systems and data extraction processes can exacerbate existing inequalities, infringe upon local privacy norms, and marginalize community voices in governance decisions.

Moreover, geopolitical tensions further amplify these challenges. Regulatory divergences between global powers—such as the European Union, the United States, and China—create fragmented governance landscapes that hinder international coordination and harmonization of AI standards. These disparities can lead to regulatory arbitrage, where corporations exploit jurisdictional differences to circumvent stringent oversight, thereby undermining global ethical standards and exacerbating inequalities in AI deployment and benefit-sharing.

To address these complexities, the Spider Vision Framework advocates intentional mechanisms for inclusive stakeholder engagement, capacity-building in less economically developed regions, and explicit attention to power imbalances in multistakeholder forums. Specifically, initiatives such as transparent stakeholder mapping exercises, resource-sharing agreements, and equitable participation protocols are recommended. By explicitly recognizing and actively addressing stakeholder complexity, power dynamics, and geopolitical concerns, the framework seeks to cultivate more inclusive, equitable, and globally coherent AI governance.

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7. Empirical Validation Pathways

Although the Spider Vision metaphor brings substantial clarity to AI governance, its true effectiveness hinges on empirical validation. By conducting pilot studies in healthcare, autonomous vehicles, and other high-risk applications, and measuring outcomes such as bias reduction and stakeholder trust, researchers can gauge the framework’s adaptability across diverse cultures and regulatory environments. Stakeholder trust will be measured through standardized survey instruments assessing perceived reliability (using a 0–10 scale), quarterly focus groups with key stakeholder representatives, and tracking user interaction patterns with AI systems. This mixed-method approach blends quantitative data with qualitative insights, ensuring a holistic understanding of trust dynamics. By systematically monitoring these metrics, governance models can be adjusted to maintain transparency and public confidence across diverse contexts.

7.1. Pilot Studies in High-Risk Domains

7.1.1. Healthcare AI

Context: Diagnostic algorithms in hospitals.
Methods: Implement a dual-focus governance protocol where AI systems (primary eyes) monitor diagnostic accuracy and bias, while human oversight (secondary eyes) assesses patient trust, cultural sensitivities, and equitable resource distribution.
Metrics: Reduction in diagnostic errors and biases (quantitative), patient feedback on trust levels and perceived fairness (qualitative).

7.1.2. Autonomous Vehicles

Context: City-wide trials of autonomous taxis.
Methods: Focused oversight includes real-time AI auditing of sensor data for collision risks, while systemic awareness involves city planning departments tracking changes in traffic flow, public acceptance, and employment shifts.
Metrics: Accident/incident rates (quantitative), stakeholder trust measured via surveys (qualitative), long-term impacts on public transportation systems (mixed methods).

7.2. Feasibility and Practical Challenges

By collecting and analyzing data from these varied contexts, researchers can refine the Spider Vision Framework, ensuring it remains both universal in principle and flexible in practice.

7.2.1. Addressing Feasibility

Real-world pilot implementations often require cross-sector collaboration, which can become resource-intensive. Acquiring institutional review board (IRB) clearance, securing funding for data-collection technologies, and aligning with local regulatory constraints all pose significant logistical and financial hurdles. Moreover, many healthcare institutions, transportation agencies, or international NGOs lack specialized personnel trained in ethical deliberation and AI oversight—an expertise gap that may require additional hiring or training expenses. Hence, early-phase pilots should include capacity-building components—such as ethics workshops, stakeholder summits, and multi-stakeholder steering committees—to ensure that moral insights inform each stage of AI deployment. Although these measures can be costly, they ultimately bolster the integrity and long-term viability of AI applications. By weaving these considerations into pilot designs, the Spider Vision Framework not only measures technical correctness but also upholds the virtues central to its mission, ultimately enhancing public trust and minimizing more serious—and potentially more expensive—ethical breaches down the line.

7.2.2. Simulation-Based Testing

While real-world pilot programs remain the gold standard for evaluating AI governance, simulation-based testing can serve as a low-risk preliminary step. For instance, digital “twins” of urban environments allow researchers to test how autonomous vehicle algorithms might adapt to varying traffic patterns, cultural norms, or emergency events. Through agent-based modeling, governance teams can experiment with different oversight protocols (i.e., adjusting the ratio of automated audits to human-led systemic monitoring) and observe how changes in governance structures impact both user safety and public trust.

The data gleaned from these simulations then inform risk mitigation strategies before large-scale deployment. In line with virtue ethics, teams can integrate a moral dimension by simulating scenarios that require prudential judgment—such as deciding between multiple ethical trade-offs in resource-limited contexts. By refining oversight structures in a controlled digital arena, the Spider Vision Framework solidifies its operational feasibility, enhancing both precision and systemic resilience.

7.2.3. Practical Constraints and Incremental Implementation Strategies

Implementing comprehensive AI governance frameworks often encounters significant practical constraints, particularly in terms of economic resources, technical expertise, and organizational capacity. For instance, resource-intensive oversight practices such as thorough algorithmic audits or extensive systemic monitoring protocols may exceed the financial or technical capacities of smaller institutions or economically developing regions. Thus, addressing these practical constraints requires clearly defined incremental implementation strategies that balance aspirational ethical goals with realistic operational capabilities.

One effective incremental strategy is phased implementation, beginning with pilot programs at a limited scale to minimize initial resource investment while gathering critical insights into feasibility and effectiveness. For example, institutions can start with targeted algorithmic audits focusing specifically on the highest-risk AI applications or most sensitive demographic impacts, gradually expanding oversight mechanisms based on results, stakeholder feedback, and acquired expertise. Additionally, leveraging open-source auditing tools, publicly available datasets, and shared best practices from international consortia can help mitigate resource constraints, especially in contexts with limited economic resources or technical capacities.

Capacity-building initiatives should also accompany incremental rollouts, including specialized training sessions, workshops, and public-private partnerships aimed at fostering local expertise in AI ethics, auditing techniques, and governance methodologies. International collaborations can further ease economic and technical burdens by sharing costs, standardizing methodologies, and pooling resources for governance activities. By explicitly recognizing and proactively addressing these practical constraints through clear, incremental implementation strategies, the Spider Vision Framework enhances its operational feasibility, accessibility, and global adaptability.

7.3. From Simulation to Real-World Implementation

A multi-phase approach to validation can blend simulation and live pilots. Early simulation helps identify glaring technical or ethical flaws, reducing the likelihood of real-world harms. Once preliminary refinements are made, smaller-scale pilot projects can provide feedback on how the framework operates under actual constraints—budgets, competing stakeholder interests, and unexpected events. Iterating between simulation and pilot tests aligns with the principle of adaptability, ensuring that final governance strategies are well-honed prior to large-scale adoption.

Moreover, validation must consider cross-cultural contexts. For instance, an AI triage system may function well in a North American healthcare environment but encounter new challenges in a region that places a different emphasis on data privacy or familial involvement in medical decisions. Systemic awareness demands that pilot studies incorporate local norms and knowledge, such as integrating community advisory boards and interpreters for regions with diverse linguistic backgrounds.

Cross-cultural validation is particularly critical in transitioning from simulations to real-world AI deployments. For example, an AI-driven educational platform piloted successfully in Europe or North America may encounter unforeseen cultural challenges when deployed in East Asia or sub-Saharan Africa, where educational norms, teacher-student relationships, and data-sharing expectations differ substantially. Therefore, pilot studies should explicitly incorporate cultural assessments, engaging local educators, students, and community leaders to adapt algorithmic designs and monitoring practices accordingly.

An incremental, phased approach can help navigate these complexities effectively. Initially, pilot implementations can focus on limited geographic or institutional settings, closely monitoring cultural adaptability and user feedback. Gradual scaling allows for ongoing adjustments informed by local insights and iterative stakeholder feedback, thus mitigating risks of unintended cultural or ethical violations. Moreover, allocating dedicated resources for cultural competence training among AI developers, policymakers, and auditors can further enhance the operational success and global applicability of the Spider Vision Framework.

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8. Future Research Directions

Generative AI has accelerated debates on data governance, intellectual property, and social manipulation. Implementing Spider Vision principles in this domain may require guidelines on model transparency, broad cultural sensitivity (e.g., how different societies perceive AI-generated art), and dynamic risk monitoring for emergent harms. Over time, an expanded version of the Spider Vision Framework might introduce automated “systemic awareness” modules, powered by advanced analytics, to flag societal shifts in real time. This automated approach, while enhancing responsiveness, still remains rooted in human virtues of prudence and justice. Ultimately, such a hybrid strategy can align leading-edge AI with the deeply human values that secure our collective well-being.

8.1. Expanded Research Possibilities

Beyond empirical validation, several avenues remain open for further research:
- Longitudinal Studies: Observing the Spider Vision Framework's long-term impacts on AI-related policymaking, public trust, and ethical cultures within organizations.
- Integrated Ethical Approaches: Exploring how consequentialist and deontological tools might best complement the virtue ethics foundation, providing multidimensional governance strategies.
- Automation of Systemic Monitoring: Developing AI-driven tools to augment human oversight of large-scale impacts, ensuring faster detection of emergent risks.
- Global Harmonization Efforts: Investigating whether an international consortium—similar to the Intergovernmental Panel on Climate Change—could coordinate the Spider Vision approach across countries, sharing data on AI governance outcomes and best practices.
- Sector-Specific Customization: Tailoring the framework to verticals like finance, education, or energy management, each of which has unique ethical and regulatory complexities (e.g., credit-scoring algorithms, adaptive learning systems, grid management by AI).
- Education and Curriculum Development: Incorporating Spider Vision principles into university curricula for computer science, data science, and ethics. This could foster a new generation of AI professionals already accustomed to thinking in terms of both focused oversight and systemic awareness.
- Comparative Studies: Conducting rigorous comparative analyses to measure how the Spider Vision Framework stacks up against purely principle-based or purely technical audit frameworks. Researchers could track key metrics such as reduced rates of algorithmic bias, improved public trust, and more holistic risk mitigation over extended time horizons.

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9. Conclusion

The Spider Vision Framework offers a novel, biomimetic approach to AI governance, emphasizing dual-focus oversight—technical precision and systemic awareness—rooted in virtue ethics. By integrating prudence, justice, and adaptability into governance structures, it addresses both immediate and long-term challenges, ensuring AI systems align with societal values and global equity.

As AI continues reshaping societies, the Spider Vision Framework lays a foundation for innovative, ethically grounded governance—contributing to a future where human virtues guide technological progress. An essential lesson from the Spider Vision analogy is that ethical governance is not a single, static initiative but a living system capable of continuous renewal. While many contemporary ethical debates around AI focus on short-term fixes or compliance checks, the Spider Vision Framework aspires to foster a culture in which virtue development and systemic mindfulness are woven into the daily practices of AI stakeholders. This is not simply a matter of institutional design—it is also about nurturing a shared moral consciousness that can unify otherwise fragmented governance efforts.

By highlighting the interplay of focused oversight and systemic awareness, this framework underscores that even the most advanced technological solutions require moral wisdom to steer them effectively. As the boundaries of AI expand from specialized tools to ubiquitous global infrastructure, adopting a biomimetic model grounded in virtue ethics may prove essential to ensuring that AI's trajectory aligns with humanity's highest aspirations, rather than its basest impulses or narrow commercial interests.

References

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

[2] Warrant, E., & Dacke, M. (2016). Visual navigation in nocturnal insects. *Physiology*, 31, 182–192.

[3] Harland, D. P., & Jackson, R. R. (2000). “Eight-legged cats” and how they see – A review of recent research on jumping spiders (Araneae: Salticidae). *Cimbebasia*, 16, 231–240.

[4] Vallor, S. (2016). *Technology and the virtues: A philosophical guide to a future worth wanting*. Oxford University Press.

[5] Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. *Nature Machine Intelligence, 1*(9), 389–399. https://doi.org/10.1038/s42256-019-0088-2

[6] United Nations Educational, Scientific and Cultural Organization. (2022). *Recommendation on the ethics of artificial intelligence*. Paris: Author. https://unesdoc.unesco.org/ark:/48223/pf0000381137

[7] Cath, C. (2018). Governing artificial intelligence: Ethical, legal, and technical opportunities and challenges. *Philosophical Transactions of the Royal Society A, 376*(2133), Article 20180080. https://doi.org/10.1098/rsta.2018.0080

[8] Schroeder, D., & Gefenas, E. (2020). Realising benefit sharing: the case of AI. *Cambridge Quarterly of Healthcare Ethics*, 29, 696–706.

[9] Brundage, M., Avin, S., Clark, J., Toner, H., Eckersley, P., Garfinkel, B., … Amodei, D. (2018). *The malicious use of artificial intelligence: Forecasting, prevention, and mitigation.* University of Cambridge Repository.

[10] Crawford, K. (2021). *Atlas of AI: Power, politics, and the planetary costs of artificial intelligence*. Yale University Press.

[11] Gstrein, O. J., Haleem, N., & Zwitter, A. (2024). General-purpose AI regulation and the European Union AI Act. *Internet Policy Review, 13*(3), Article 1790. https://doi.org/10.14763/2024.3.1790

[12] Bostrom, N. (2014). *Superintelligence: Paths, Dangers, Strategies.* Oxford University Press.

[13] Khanal, S., Zhang, H., & Taeihagh, A. (2024). Why and how is the power of big tech increasing in the policy process? The case of generative AI. *Policy & Society, 43*(2), 210–229. https://doi.org/10.1093/polsoc/puad012.

[14] *Birhane, A. (2020). Algorithmic colonization of Africa. SCRIPT-ed, 17*(2), 389–409.

[15] *Whittlestone, J., Nyrup, R., Alexandrova, A., & Cave, S. (2019). The role and limits of principles in AI ethics: Towards a focus on tensions. Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society* (pp. 195–200).

[16] *Mancilla-Caceres, J. F., & Estrada-Villalta, S. (2022). The ethical considerations of AI in Latin America. Digital Society, 1*(2), 1–6.

[17] *Mhlambi, S. (2020). From Rationality to Relationality: Ubuntu as an Ethical and Human Rights Framework for Artificial Intelligence Governance. Carr Center Discussion Paper, Harvard Kennedy School.*

[18] Brundage, M., Avin, S., Clark, J., Toner, H., Eckersley, P., Garfinkel, B., … Amodei, D. (2018). The malicious use of artificial intelligence: Forecasting, prevention, and mitigation. *arXiv preprint arXiv:1802.07228*.

[19] Nasir, S., Khan, R. A., & Bai, S. (2024). Ethical Framework for Harnessing the Power of AI in Healthcare and Beyond. *IEEE Access*, 12, 31014–31035.

[20] Dennis, C., Clare, S., Hawkins, R., Simpson, M., Behrens, E., Diebold, G., Kara, Z., Wang, R., Trager, R. F., Maas, M., … Ziosi, M. (2024). *What should be internationalised in AI governance?* Oxford Martin AI Governance Initiative Policy Paper. Retrieved from https://www.oxfordmartin.ox.ac.uk/publications/what-should-be-internationalised-in-ai-governance/

[21] Zhang, Y., & Lee, A. (2023). AI governance frameworks: A comparative review. *Technology in Society, 72*, 101993.

[22] Mancilla-Caceres, J. F., & Estrada-Villalta, S. (2022). The ethical considerations of AI in Latin America. *Digital Society, 1*(2), 1–6.

[22] Goffi, E. (2021). Escaping the Western cosm-ethical hegemony: The importance of cultural diversity in the ethical assessment of artificial intelligence. *AI Ethics Journal, 2*, 1–11.

[23] Fjeld, J., Achten, N., Hilligoss, H., Nagy, A., & Srikumar, M. (2020). Principled artificial intelligence: Mapping consensus in ethical and rights-based approaches to principles for AI. *Berkman Klein Center for Internet & Society at Harvard University.*

[24] Floridi, L. (2021). Translating principles into practices of digital ethics: Five risks of being unethical. *Philosophy & Technology, 34*(3), 459–471.

[25] Foelix, R. F. (2011). *Biology of spiders* (3rd ed.). Oxford University Press.