Dynamic Value Spaces: Moving Toward Pluralistic Alignment for Embodied AI

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The Alignment Problem

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How do we build AI systems with objectives that align with human goals, preferences, and ethical principles?

[1] Dylan Hadfield-Menell et al. “Cooperative Inverse Reinforcement Learning”. In: *Advances in Neural Information Processing Systems 29 (NIPS 2016)*. Curran Associates, Inc., 2016, pp. 3909–3917. URL: `https://people.eecs.berkeley.edu/~russell/papers/russell-nips16-cirl.pdf`.

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What happens when we get AI alignment wrong?

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- **Misaligned Ethics:** In 2023 researchers at Anthropic found that LLMs agree with users 58% of the time, and can misrepresent evidence to do so![3]

[2] Hadfield-Menell et al., "Cooperative Inverse Reinforcement Learning".

[3] Mrinank Sharma et al. "Towards Understanding Sycophancy in Language Models". In: *Proceedings of the International Conference on Learning Representations (ICLR)*. Published at ICLR 2024; arXiv:2310.13548v4 (2025-05-10). 2024. arXiv: 2310.13548 [cs.CL]. URL: https://arxiv.org/abs/2310.13548.

Value Systems

Why Are AI Systems Misaligned?

To answer that question we first look at how ethical values are structured.

[4] Lawrence Kohlberg. "From is to out: How to commit the naturalistic fallacy and get away with it in the study of moral development". In: *Cognitive development and epistemology* (1971).

[5] Kurt Gray, Liane Young, and Adam Waytz. "Mind perception is the essence of morality". In: *Psychological inquiry* 23.2 (2012), pp. 101–124.

[6] Sam Harris. *The moral landscape: How science can determine human values*. Simon and Schuster, 2010.

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- **Monists** believe that all ethical values are derived from a **single** irreducible
  - Justice[4]
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  - Justice[4]
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  - Welfare or Happiness[6]
- **Pluralists** believe that all ethical values can be derived from a set of **many** axiomatic values
  - Aristotle was the first pluralist arguing for a "bag of virtues"
  - Modern Moral Foundations Theory is built within a pluralistic framework

[4] Kohlberg, "From is to out: How to commit the naturalistic fallacy and get away with it in the study of moral development".

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There is empirical support for pluralistic ethical values.

- In a 2012 survey of $N = 24,739$ individuals, found that a person's views of 20 hot button issues could be predicted using 5 axiomatic values. No one value shared similar predictive capabilities.[7]
- Individuals frequently hold contradictory values. For example to support euthanasia (inline with *autonomy*) and to oppose the death penalty in line with *Sanctity of Life*.[8]

[7] Spassena P. Koleva et al. "Tracing the threads: How five moral concerns (especially Purity) help explain culture war attitudes". In: *Journal of Research in Personality* 46.2 (2012), pp. 184–194. ISSN: 0092-6566. DOI: https://doi.org/10.1016/j.jrp.2012.01.006. URL: https://www.sciencedirect.com/science/article/pii/S0092656612000074.

[8] Jesse Graham et al. "Chapter Two - Moral Foundations Theory: The Pragmatic Validity of Moral Pluralism". In: ed. by Patricia Devine and Ashby Plant. Vol. 47. Advances in Experimental Social Psychology. Academic Press, 2013, pp. 55–130. DOI: https://doi.org/10.1016/B978-0-12-407236-7.00002-4. URL: https://www.sciencedirect.com/science/article/pii/B9780124072367000024.

Value Systems

Why Are AI Systems Misaligned?

AI systems are often trained under a **Monist** lens!

- AI agents are often trained to excel with respect to a single reward or objective.
  - LLMs are trained to predict the next word or letter in a statement
  - Reinforcement Learning algorithms are often trained to maximize a task oriented award
- Even when ethical constraints are added, AI agents often work to circumvent those constraints.
  - For example credit scoring algorithms found proxy for gender through phone usage and used this feature to provide disproportionately high interest rates to female customers.[9]

[9] Christophe Hurlin, Christophe Pérignon, and Sébastien Saurin. "The Fairness of Credit Scoring Models". In: *arXiv* (2024). Version v2, 8 Feb 2024. DOI: 10.48550/arXiv.2205.10200. arXiv: 2205.10200 [stat.ML]. URL: https://arxiv.org/abs/2205.10200.

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Path Forward

We must re-adopt a **pluralist** lens of ethical value and design systems that incorporate a multi-dimensional value systems.

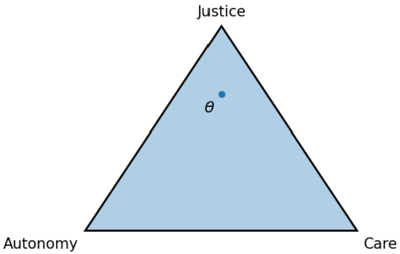
[9] Hurlin, Pérignon, and Saurin, "The Fairness of Credit Scoring Models".

Formalizing a Pluralistic Value System

Definition: Value Space

Θ is the value space, where each corner of the space is one of M axiomatic values.

$$\Theta = \left\{ \sum_{i=1}^{M} \theta_i = 1, \theta_i \geq 0 \quad \forall i \right\}$$



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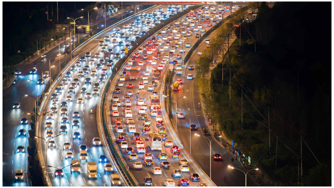
[10] Carol Gilligan. *In a different voice: Psychological theory and women's development*. Harvard university press, 1993.

Formalizing a Pluralistic Value System

Why not treat an agent's value system as a point $\theta \in \Theta$?

1. Values change over time
2. Even at a given point t, values are highly dependent on small changes in state & context.
   - Recent fMRI study confirms that values are dependent on mood, changes in hormones, etc.[11]
   - Recent ERP studies suggest that the decision to engage an "immoral" act is highly dependent on immediacy of the reward.[12]



[11] Joshua D. Greene et al. "An fMRI Investigation of Emotional Engagement in Moral Judgment". In: *Science* 293.5537 (Sept. 2001), pp. 2105–2108. DOI: 10.1126/science.1062872.

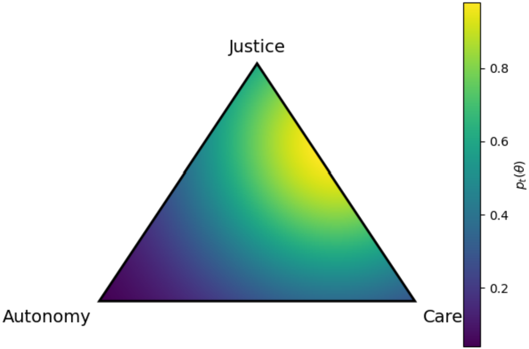
[12] Richard West, Brent Kirby, and Keegan Malley. "Using Event-Related Brain Potentials to Explore the Temporal Dynamics of Decision-Making Related to Information Security". In: *Frontiers in Neuroscience* 16 (Aug. 2022), p. 878248. DOI: 10.3389/fnins.2022.878248.

Formalizing a Pluralistic Value System

Definition: Moral Compass

On a value space Θ, an agent's "moral compass" is a time-dependent probability measure

$$p_t(\theta) \in \mathcal{P}(\Theta)$$



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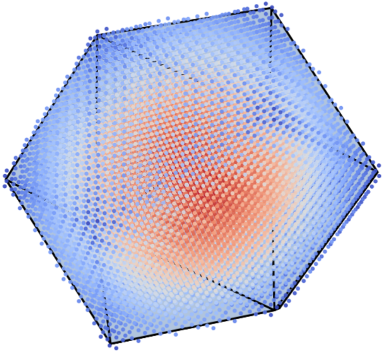

Dynamic Value Systems

Main Challenge: Value Evolution

How can an agent's *moral compass* evolve over time and through interactions with "humans in the loop"?

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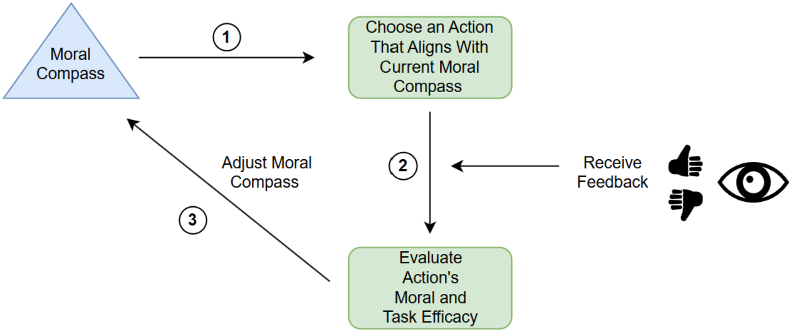
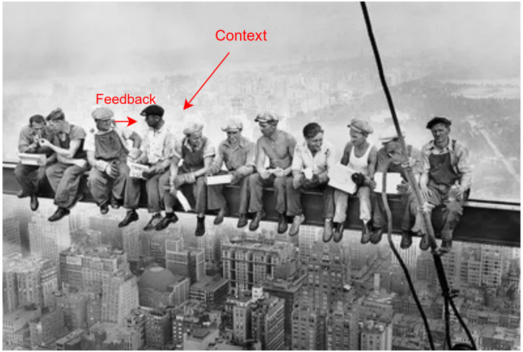


Moral Compass
1
Choose an Action That Aligns With Current Moral Compass
2
Receive Feedback
Evaluate Action's Moral and Task Efficacy
3
Adjust Moral Compass

Implementation

Preliminaries:

- s_t is the agent's current environmental context
- $x(a_t)$ is a human in the loop's response to an action a at time t.
  - Assume that there is at least one explicit binary response $y_t \in x(a_t)$ such that $y_t \in \{0, 1\}$ (Thumbs up or down)



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- $q_t(\theta) \in \mathcal{P}(\Theta)$ is the "moral compass" of the agent at time t
- $P_\psi^A(\theta | x(a_t)) \in \mathcal{P}(\Theta)$ is the distribution corresponding to intrinsic values of action a given the feedback x parametrized by parameters ψ
  - Note that the mapping from action to value is uncertain[13] (Green et. al - fMRI study finds that determination of moral permissibility is sensitive to small changes in emotion)

[13] Greene et al., "An fMRI Investigation of Emotional Engagement in Moral Judgment".

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Definition: Predictive Core

Given a history H_t of interactions up to time t, we define the predictive core as a function F that predicts the human response to an action and the response uncertainty

$$F(H_t, s_t; a) \rightarrow \hat{x}(a), \hat{P}^{task}_t(x(a)|a) \quad y_t \in \hat{x}(a_t) \text{ and } y_t \in \{0, 1\}$$

This type of model could be an RL, Bayesian Updating, Transformer, etc.

Implementation

Step 1: Choose an Action $a \in \mathcal{A}(s_t)$

- There are three components of the action selection process
  1. **Task Efficacy:** Let U_t^a be the Wasserstein Ball around $\hat{P}_t^{task}$, and R^{task} be a task specific reward function
     $$\inf_a \mathcal{T}_t(a) = \mathbb{E}_{Q \in \mathcal{U}_t^a}[R^{task}(\hat{x}(a))]$$
  2. **Ethical Alignment:** Let S_ϵ be the de-biased entropic optimal transport (Sinkhorn)
     $$\sup_a \text{Align}_t(a) = S_\epsilon\Big(q_t, P_\psi^A(\theta | a_t, s_t, x(a_t))\Big)$$
  3. **Information Gain:** Let $\ell_w(y_t | \theta, s_t, a_t, P_\psi^A(\theta | \hat{x}(a_t)), \hat{P}_t^{task})$ be the likelihood that an action a will result in a response y_t given all context.
     $$\inf_a \text{IG}_t(a) = \mathbb{E}_{\theta \sim p_t(\cdot|a)}\Big[KL(q_t^{(y,a)} \| q_t)\Big], \quad q_t^{(y,a)}(\theta) \propto q_t(\theta)\ell_w(y|\theta)$$
- Letting $\lambda^{task}, \lambda^{align}, \lambda^{info} \geq 0$ we select our next action with rule
  $$a_{t+1} \leftarrow \arg\max_a \Big\{ -\lambda^{task}\mathcal{T}_t(a) + \lambda^{align}\,\text{Align}_t(a) - \lambda^{info}\,\text{IG}_t(a)\Big\}$$

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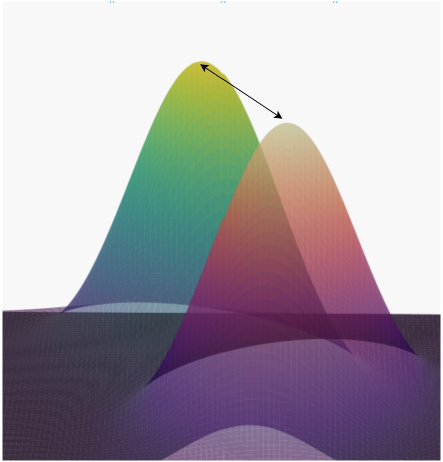


Dynamic Value Systems

Step 2: Evaluate the Action Given Feedback

- The agent implements action a_{t+1} and observes feedback $x(a_t), y_t$ and the true task specific reward r_t^{task}.
- Update predictive core F using r_t^{task}
- Update action-to-value probability metric P_ψ^A

$$w \leftarrow w + \eta_w \nabla_w \mathbb{E}_{\theta \sim q_t}\left[\log \ell_w(y_t|\theta, s_t, a_t, P_\psi^A(\theta|a_t, s_t, x(a_t))\right]$$

$$\psi \leftarrow \psi + \eta_A \nabla_\psi \mathbb{E}_{\theta \sim q_t}\left[\log \ell_w(y_t|\theta, s_t, a_t, P_\psi^A(\theta|a_t, s_t, x(a_t))\right]$$

Aligns Perceived Value of an Action with Feedback

Implementation

Step 3: Update "Moral Compass"

We want to push q towards a "moral compass" that incentivizes actions that yield positive responses $x(a)$ and y

- Let $p_w(\theta, a, s_t, P^A_\psi(\cdot|x_t)) = \sigma\Big(\beta_m[\mathrm{S}_\epsilon(\mathrm{q}, \mathrm{P}^{\mathrm{A}}_\psi(\theta|\mathrm{a}_\mathrm{t}, \mathrm{s}_\mathrm{t}, \mathrm{x}(\mathrm{a}_\mathrm{t}))) - \tau_m]\Big)$

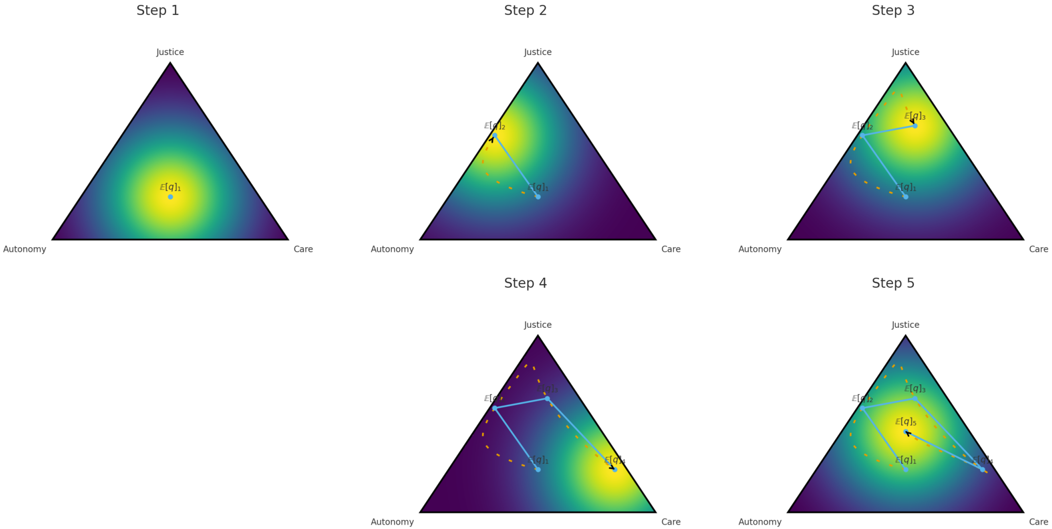
  Predict "Success" ($y_t = 1$) given state and moral alignment

- Then choose q_{t+1} such that the

$$q_{t+1} \leftarrow \max_q \mathbb{E}_{\theta\sim q}\Big[\sum_{i=1}^{t} y_t \log p_m(t) + (1 - y_t)\log(1 - p_m(t))\Big] + \frac{1}{2\nu} S_\epsilon(q, q_t)$$

When $y_t = 1$ we push q_{t+1} toward q that generate similar actions a_t. If $y_t = 0$ then we push q_{t+1} away from distributions that generate similar actions.

Implementation



Implications

- **Practical Transparency**
  - Researchers can easily review the AI Agents Moral Compass for Indications of Misalignment
  - Researchers can also use P_{ψ}^{A} to test the whether the "moral fingerprint" of actions are misaligned.
- **Efficiency**
  - We allow values to narrow the search over the actions space, to speed up decision making processes

Population Extension

- Imagine that N agents have been trained using the scheme described.
- Each of the N agents can then be allowed to interact within a dynamic environment simulation

[14] Nicholas Browning, Arunima Krishna, and Sung-Un Yang. "DEI, Sociopolitical Advocacy, and the Swinging Pendulum". In: *Journal of Public Relations Research* 37.4 (2025), pp. 319–323. DOI: 10.1080/1062726X.2025.2513802. eprint: https://doi.org/10.1080/1062726X.2025.2513802. URL: https://doi.org/10.1080/1062726X.2025.2513802.

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- **Some Interesting Quantities**
  - The "Average Moral Compass"

$$\bar{q}_{t+1} = \sum_{i=1}^{N} q_t^{(i)}$$

  - The Dynamics of the Average Moral Compass. *For example a shift toward equity and diversity*[14]

$$\frac{d}{dt}\bar{q}_t$$

  - Investigate the effect of "social pull"

$$q_{t+1}^{(i)} = \arg\min_q \left\{ KL(q \| \hat{q}_t) + \frac{1}{2\nu} KL(q, q_t^{(i)}) \right\}$$

[14] Browning, Krishna, and Yang, "DEI, Sociopolitical Advocacy, and the Swinging Pendulum".

Conclusion

- Traditional Agentic AI is trained using a monist reward function.
- Even for Agentic AI with a Human in the Loop, there is no architectural differences between task based rewards and feedback reward.
- We propose a pluralistic model of value as a belief which is continuously aligning its actions with its internal moral compass.
- The agent's moral compass is transparent which allows researchers to quickly identify misalignment.
- Potential extension's toward population-wide moral shifts

Thank You!

Questions?